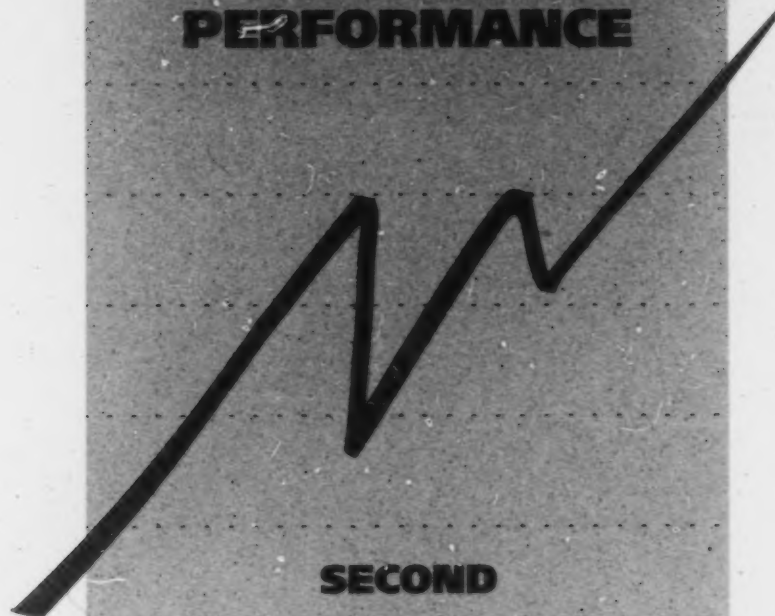


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**PETROLEUM
INDUSTRY
ENVIRONMENTAL
PERFORMANCE**



SECOND

ANNUAL

REPORT



This report is part of STEP—Strategies for Today's Environmental Partnership—an industry-wide program built on 11 guiding environmental principles that became part of API's bylaws in 1990 (see inside back cover). STEP aims to address public concerns by improving our industry's environmental, health, and safety performance; documenting performance improvements; and communicating them to the public. For more information about STEP, please contact:

American Petroleum Institute
1220 L Street, N.W.
Washington, D.C. 20005
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If you wish to order copies of this report or other API publications, please call 202-682-8375.

This is the petroleum industry's second environmental performance report. Published by the American Petroleum Institute, it is part of a long-term program called STEP—Strategies for Today's Environmental Partnership.

Our first environmental performance report, published in 1992, had four sections: chemical releases, oil spills, workplace safety, and environmental expenditures. This report has six sections: the four included in the last report plus two new sections on refinery residuals and used oil.

The analyses of chemical releases, oil spills, and workplace safety are based largely on U.S. government statistics—from the Environmental Protection Agency, the Coast Guard, and the Occupational Safety and Health Administration. The rest of the report is based on surveys API conducted on its own or in conjunction with other industry groups.

Most of the statistics are current through 1992. Historical information is included where possible. Though some of the data are so recent it is too early to detect trends, they provide a basis for future comparisons. Our hope is that this report will be used as a yardstick—to assess our industry's performance and measure its progress.

May 1994

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executive summary

Our second environmental performance report builds upon the first—in scope and depth. Additional information on chemical releases, oil spills, workplace safety, and environmental expenditures permits more informed trend analysis. The new section on refinery residuals includes five years of data so it, too, suggests trends. The second new section—on used oil—establishes a baseline for future analysis.

CHEMICAL RELEASES

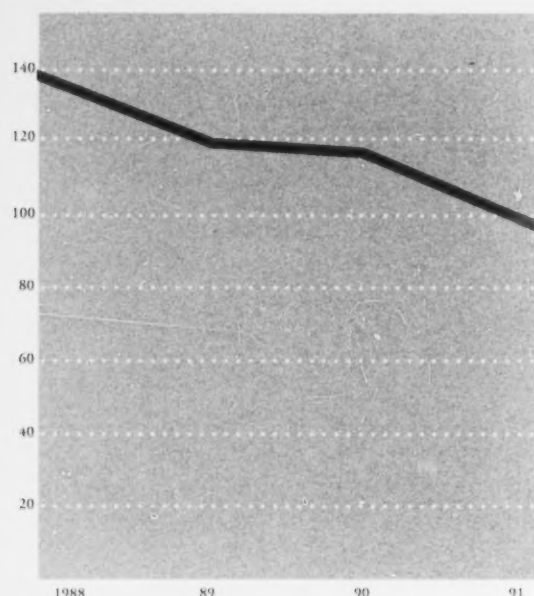
By law, the U.S. Environmental Protection Agency must inform the public of chemical releases from industrial facilities such as refineries. It does this through the Toxics Release Inventory (TRI), an annual survey of more than 300 chemicals that includes 116 known or suspected carcinogens.

In 1991 (the latest data available), petroleum refining ranked eighth among U.S. industries in TRI volume, contributing about 2 percent of the releases from U.S. industry as a whole—largely ammonia and hydrocarbons. Known or suspected carcinogens constituted less than one-tenth of all TRI releases; petroleum refineries produced about 3 percent of this subset of releases—mainly benzene.

Overall, chemical releases from refineries declined by 27 percent between 1988 and 1991. The bulk of those releases were emitted into the air or injected underground. But the most recent data show underground injection starting to decline: volume dropped by one-third between 1990 and 1991.

The 1990 Pollution Prevention Act expanded TRI reporting requirements, requiring refineries and industrial plants to gather additional data on waste management and pollution prevention. Because EPA did not start collecting this data until 1991—and has yet to provide guidance on reporting requirements—it will be several years before the TRI provides accurate information in these areas.

**REFINERY RELEASES AND TRANSFERS
OF TRI CHEMICALS: 1988-1991**
(in millions of pounds)



Refineries' releases and transfers of TRI chemicals declined by 27 percent between 1988 and 1991.

REFINERY RESIDUALS

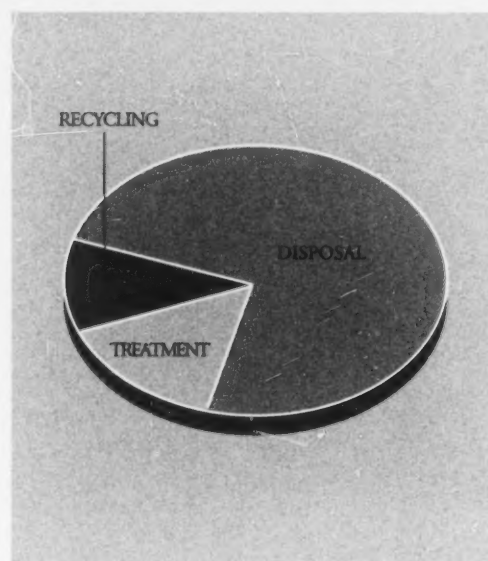
Each year since 1987, API has conducted an industry-wide survey on the nature and volume of wastes and other by-products of petroleum refining—and how the industry manages them. The survey tracks 30 types of materials, eight of which the Resource Conservation and Recovery Act classifies as hazardous wastes—mostly sludges.

In 1991 (the latest data available), U.S. petroleum refineries managed some 14.8 million tons of wastes and other residual materials—3.4 million less than the year before and the lowest amount since API started conducting its survey. Refinery residuals had risen sharply in 1990 when the U.S. Environmental Protection Agency issued final regulations on hazardous wastes. The increase was a harbinger of environmental progress—a reflection of refineries' quick response to the new regulations.

Unspecified aqueous wastes were about two-thirds of the refinery residuals generated between 1987 and 1991. Most of those wastes came from a small number of refineries, which disposed of them by

injecting them underground. But that is changing. As API's waste management survey shows, refineries are recycling more and discarding less—though disposal is still the main means of handling wastes and will remain so indefinitely.

RESIDUALS BY MANAGEMENT METHOD: 1991
(percent of total weight)



Refineries dispose of 74 percent of their residual materials, treat 15 percent, and recycle 11 percent.

OIL SPILLS

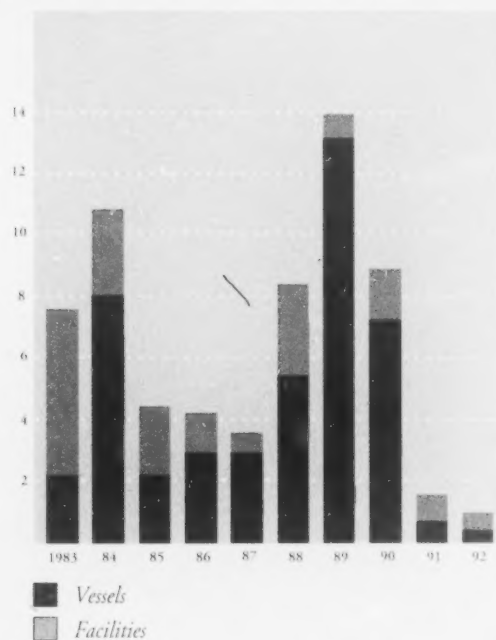
Two broad trends in oil spills in U.S. waters emerged in the latter half of the most recent decade for which Coast Guard records are available, the years 1983 through 1992. The number of small spills rose (possibly a function of better reporting), yet the amount of oil spilled dropped precipitously: from 14 million gallons in 1989 to 1 million gallons in 1992.

The decline illustrates the impact of large spills on the overall picture. In 1989, for example, a single spill accounted for more than three-fourths of the total volume spilled; in 1990, a single spill was close to half the total. While most oil spills in U.S. waters come from vessels and facilities owned by entities other than the petroleum industry—the U.S. government, the armed forces, other industries, and

private citizens—most of the large spills come from tankers or barges controlled by oil companies.

Though infrequent, these large spills have a big impact on public perceptions. And little heed is paid to the fact that relative to how much oil Americans use, only a tiny amount spills: three-thousandths of one percent—0.003 percent—of the 2.5 trillion gallons of petroleum products Americans used between 1983 and 1992.

TOTAL VOLUME OF OIL SPILLS: 1983-1992
(in millions of gallons)



Volume has declined dramatically with the drop in large oil spills.

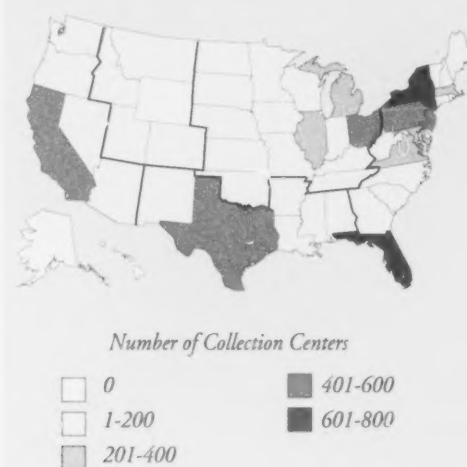
USED OIL

Each year, “do-it-yourselfers”—people who change their own motor oil—generate 200 million gallons of used oil, according to the U.S. Environmental Protection Agency. If disposed of improperly, that oil can contaminate soil and water—both on the surface and underground.

Oil companies have joined forces with government agencies—federal, state, and municipal—to prevent that by creating used oil collection programs and educating people about them. An API survey shows that oil companies have established some 7,000

drop-off collection sites in service stations, convenience stores, and fast oil-change facilities across the country. In 1992, those sites took in more than 7 million gallons of used oil.

USED OIL COLLECTION CENTERS
OPERATED BY 15 OIL COMPANIES: 1992



More than half the collection centers were in the Eastern United States.

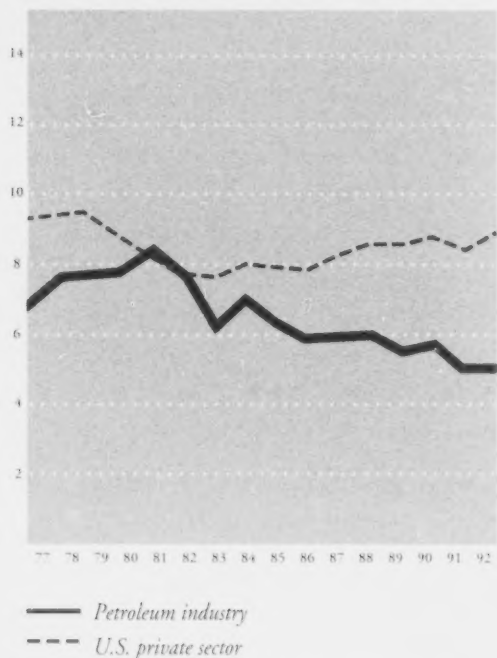
WORKPLACE SAFETY

Job-related injuries and illnesses among petroleum workers fell by 26 percent between 1977 and 1992, U.S. Occupational Safety and Health Administration and API records show. Some parts of the petroleum industry did even better during those 16 years: injuries and illnesses dropped by 48 percent among exploration and production workers, 40 percent among oil pipeline workers, and 28 percent among refinery workers. In the marketing sector, job-related injuries and illnesses declined by 2 percent over the period.

The downward trend has moderated in recent years—and, in some sectors of the industry, leveled off. In part, this may reflect changes in record-keeping requirements introduced in 1986. Reports of injuries and illnesses subsequently rose—for parts of the petroleum industry and much of the rest of

the private sector. Still, the petroleum industry has bettered the average for the U.S. private sector virtually every year—and, in contrast to the private sector as a whole, continued to improve.

**PETROLEUM INDUSTRY AND U.S. PRIVATE SECTOR
OCCUPATIONAL INJURIES AND ILLNESSES: 1977-1992**
(per 100 full-time workers)



Injuries and illnesses among petroleum workers dropped 26 percent—compared to 4.3 percent for the entire U.S. private sector.

ENVIRONMENTAL EXPENDITURES

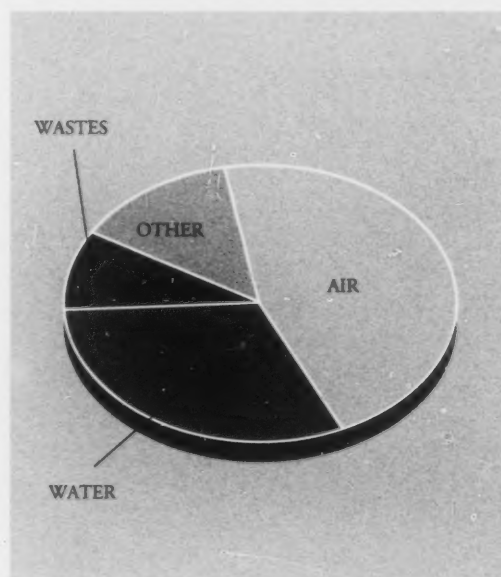
The petroleum industry spent \$10.5 billion on the environment in 1992—as much as the top 300 oil and gas companies earned in profits that year and more than the entire industry spent searching for oil and gas in the United States. With oil going for \$16 per barrel at the wellhead, the industry spent \$4 on environmental protection for every domestically produced barrel of oil—\$41 for every man, woman, and child in America.

The petroleum industry's environmental expenditures have risen by more than one-third in three years: from \$7.8 billion in 1990 to \$10.5 billion in 1992. The emphasis has changed as well. At the start of the period, the largest share of those

expenditures was to prevent water pollution; by the end, spending to reduce air pollution had taken the lead.

The increase in environmental expenditures reflects the impact of the 1990 Clean Air Act amendments—for example, the need to equip refineries to make diesel fuel containing less sulfur. Overall, spending related to air pollution has more than doubled. In 1992, the refining sector spent \$5.8 billion on ongoing environmental activities—far more than all other parts of the industry combined. The exploration and production sector was next at \$1.6 billion, followed by the transportation sector at \$1.0 billion and the marketing sector at \$0.6 billion.

**U.S. ENVIRONMENTAL EXPENDITURES FOR ONGOING
ENVIRONMENTAL ACTIVITIES BY MEDIA: 1992**



The petroleum industry spends more to reduce air emissions than any other form of pollution.

chemical releases



This section analyzes petroleum refineries' chemical releases from 1988 through 1991. It describes where they go and discusses how they compare—in quantity and character—to those of other industries.

The analysis is based on the U.S. Environmental Protection Agency's annual Toxics Release Inventory. Established by the 1986 Emergency Planning and Community Right-to-Know Act (an expansion of the Superfund law first passed in 1980), the TRI covers more than 300 chemicals, including 116 that meet the U.S. Occupational Safety and Health Administration's definition of a carcinogen. By law, some 23,000 manufacturing plants must determine which TRI chemicals they release, estimate their weight, and report to EPA where they go.

Until 1990, this information was broken down into five categories: air releases, water releases, land releases, underground injection, and off-site transfers. Then, the 1990 Pollution Prevention Act expanded TRI reporting requirements. Now, plants must also provide data on waste management and pollution prevention practices.

The new information, reported for the first time in 1991, is broken down into the categories of energy recovery, recycling, and source reduction—both on- and off-site. These data are qualitatively different from the other TRI data; they address methods of waste management rather than chemical releases to the environment. Accordingly, they are presented separately in this report.

The TRI reporting threshold—which applies to all plants with 10 or more full-time employees—was 50,000 pounds in 1988. In 1989, the threshold dropped to 25,000 pounds for manufacturing or processing a listed chemical and 10,000 pounds for otherwise using a listed chemical. There it remains.

Because of the way EPA assigns identifying codes, the records sometimes attribute releases from petroleum refineries to other sources—for example, to petrochemical plants on the same site. Conversely, the records sometimes attribute other sources' releases to refineries.

API amended EPA's data to ensure that this report includes all releases from petroleum refineries—and only petroleum refineries. Toward that end, API checked EPA's list of refineries against its own records, U.S. Department of Energy records, and lists of refineries published in the Oil & Gas Journal and the Penn Well Directory. Where EPA records showed large year-to-year fluctuations in releases, API contacted the refinery for verification.

API also asked all refineries for the details of their 1991 releases. About one-third of the refineries complied with this request, enabling API to check for inconsistencies in EPA's records.

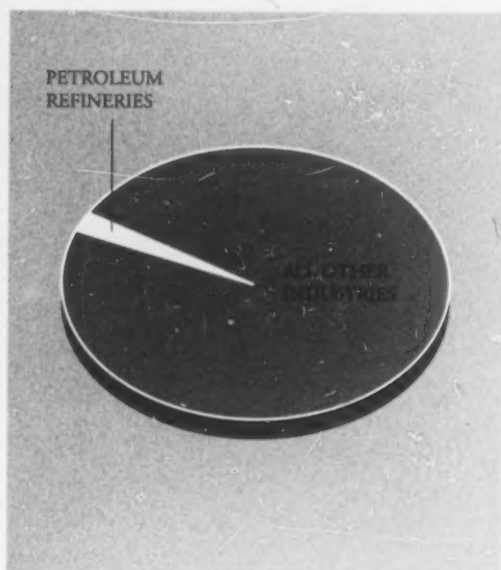
DEFINITIONS

EPA requires plants and factories to use the categories below for chemical releases and waste management practices covered by the Toxics Release Inventory.

Air releases. Chemicals an industrial facility emits into open air. Sources may be either "point" or "non-point" (also known as fugitive emissions). Point sources include stacks, vents, ducts, and pipes. Non-point sources include leaks from valves, pump seals, flanges, and compressors; evaporation from surface impoundments and spills; and leaks from building ventilation systems.

figure 1

INDUSTRIAL RELEASES AND TRANSFERS OF
TRI CHEMICALS BY SOURCE: 1991
(percent of total weight)



Petroleum refineries contribute about 2 percent of the chemical releases and transfers EPA tracks with its annual Toxics Release Inventory.

Energy recovery. Burning wastes in furnaces, kilns or boilers to generate energy for use at the same site. Does not include incineration.

Land releases. Chemicals stored or treated on land that is part of the facility site. They may be disposed of by burial in a landfill, broken down by incorporation in the soil (land farming) or deposited in surface impoundments—ponds, lagoons or pits. EPA also categorizes leaks and spills from facilities as land releases—for example, from underground pipelines and storage tanks.

Off-site transfers. Chemicals transported to off-site facilities for treatment or disposal. Such facilities include public sewage treatment plants—in EPA terminology, Publicly Owned Treatment Works (POTWs).

Recycling. Recovering materials from wastes for the same or another use—for example, catalysts and metals. Includes regeneration—restoring the operative properties of solvents, resins, and other materials so they can be reused.

Source reduction. Reducing or eliminating waste by preventing it in the first place—at the source. Accomplished by changing processes, feedstocks or increasing efficiency.

Underground injection. Chemicals deposited underground in deep wells on the facility site—wells regulated under the Resource Conservation and Recovery Act and the Safe Drinking Water Act. Requires certain geological conditions: a porous layer of soil or rock (about a mile deep) that allows wastes to disperse, topped by an impermeable formation such as clay, which serves as a seal and

table 1

INDUSTRIAL RELEASES AND TRANSFERS OF
TRI CHEMICALS: 1988-1991
(in pounds)

Year	All industries		Refineries	
	Weight*	Percent Change (compared to 1988)	Weight	Percent Change (compared to 1988)
1988	6,426,484,611	—	135,247,928	—
1989	5,705,670,380	-11%	120,532,393	-11%
1990	4,830,980,821	-25%	115,218,695	-15%
1991	4,458,805,714	-31%	98,359,970	-27%

*Current as of final EPA publication for the year.

prevents contact with usable groundwater. Well operators must demonstrate to EPA that hazardous wastes injected into such formations will remain there for at least 10,000 years.

Water releases. Chemicals an industrial facility is permitted to discharge into a river or other surface body of water under EPA's National Pollutant Discharge Elimination System (NPDES). Discharge points include pipes, waste treatment systems, and storm drains.

RESULTS

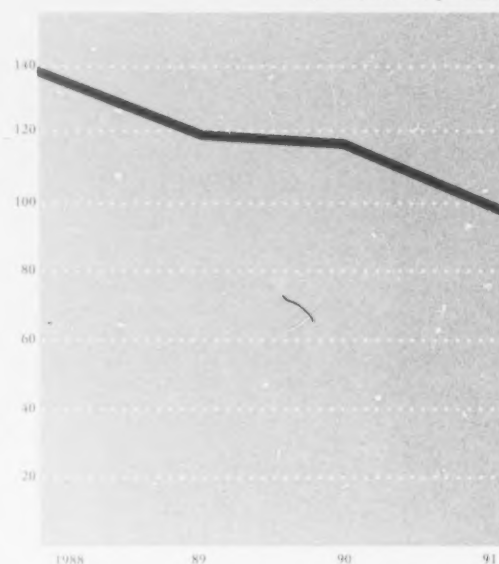
Petroleum refineries generate just over 2 percent of the chemical releases EPA tracks through the TRI (see Figure 1). Overall, the volume of releases is declining—for refineries (see Figure 2) and U.S. industry as a whole.

EPA started collecting TRI data in 1987, but uses the 1988 data as a baseline because they are more accurate. Between 1988 and 1991, refineries' releases dropped by 27 percent and releases from all industries dropped by 31 percent (see Table 1). In 1991, petroleum refining ranked eighth among U.S. industries in chemical releases (see Table 2).

Refineries emit most of their releases into the air or inject them underground. The most recent data show that underground injection has declined by one-third: from 37.4 million pounds in 1990 to 23.7 million pounds in 1991.

figure 2

REFINERY RELEASES AND
TRANSFERS OF TRI CHEMICALS: 1988-1991
(in millions of pounds)



Refineries' releases and transfers of TRI chemicals declined by 27 percent between 1988 and 1991.

table 2

MAJOR INDUSTRIES' RELEASES AND
TRANSFERS OF TRI CHEMICALS BY CATEGORY: 1991
(in pounds)

Industry	Weight	Air Releases	Water Releases	Land Releases	Underground Injection	Off-site Transfers
Chemicals	2,065,114,191	29.8%	9.1%	4.4%	31.8%	24.9%
Primary metals	595,202,506	26.2	1.4	42.8	2.3	27.3
Paper	298,410,927	69.8	9.9	1.4	0.0	18.9
Transportation	182,426,089	80.5	0.1	1.1	0.0	18.3
Plastics	171,896,220	87.9	0.3	0.3	0.0	11.5
Fabricated metal	159,071,135	67.9	0.2	1.0	0.0	30.9
Electrical	108,556,283	60.5	0.4	1.4	0.0	37.7
Petroleum refining	98,359,970	65.5	3.7	1.5	24.1	5.2
Food	83,318,464	34.2	2.9	10.8	0.3	51.8
Furniture	57,995,909	94.5	0.0	0.5	0.0	5.0
All other industries	638,454,020	64.4	1.6	8.8	2.6	22.6
Total	4,458,805,714	45.1	5.5	9.5	15.9	24.0
Petroleum refining's share of the total	2.2%	3.2%	1.5%	0.3%	3.3%	0.5%

table 3

**MOST COMMON REFINERY RELEASES AND
TRANSFERS OF TRI CHEMICALS BY CATEGORY: 1991**
(in pounds)

Chemical	Air Releases	Water Releases	Land Releases	Underground Injection	Off-site Transfers	Total
Ammonia	7,920,581	3,003,321	26,514	21,613,500	214,379	32,778,295
Toluene	12,306,606	16,230	48,292	105,002	129,843	12,605,973
Propylene	8,189,079	4,627	0	0	41	8,193,747
Xylenes (mixed isomers)	7,032,001	16,356	102,543	35,353	170,881	7,357,134
Benzene	5,611,824	9,989	91,833	108,390	138,008	5,960,044
Methyl ethyl ketone	5,769,655	5,807	2,276	36,000	896	5,814,634
Ethylene	3,254,462	4,500	0	0	17	3,258,999
Cyclohexane	2,308,956	4,506	9,060	2,554	20,106	2,345,182
Phenol	343,494	25,220	21,368	1,247,302	170,923	1,808,307
Ethylbenzene	1,642,801	6,833	19,872	5,400	48,448	1,723,354
Subtotal	54,379,479	3,097,389	321,758	23,153,501	893,542	81,845,669
All other chemicals	10,084,816	568,750	1,117,913	568,334	4,174,488	16,514,301
Grand total	64,464,295	3,666,139	1,439,671	23,721,835	5,068,030	98,359,970

Most common refinery releases. Ten chemicals account for more than 80 percent of refineries' releases (see Table 3). First in volume is ammonia. It is created when nitrogen, a contaminant, is removed from crude oil.

Most of the other chemicals refineries release are hydrocarbons known as olefins and aromatics. The olefins (ethylene and propylene) form when crude oil is refined. The aromatics (benzene, toluene, and xylene) are present in crude oil; they are also created when it is refined. Used to make gasoline, these chemicals are also the raw material of a variety of consumer products: solvents, detergents, adhesives, resins, and synthetic fibers such as polyester and nylon.

Top-25 TRI chemicals. Releases of the top-25 in volume—more than 80 percent of all TRI releases—declined by more than one-fourth between 1988 and 1991. Refineries' releases of the top-25 declined at about the same rate.

Between 1988 and 1991, refineries' ammonia releases declined even more, going from 48 million pounds or 12.6 percent of the 1988 total to 33 million pounds or 5.5 percent of the 1991 total (see Table 4). Most of this ammonia is disposed of by underground injection (see Table 5) at five refineries.

table 4
RELEASES AND TRANSFERS OF
TOP-25 TRI CHEMICALS: 1988 & 1990-1991
(in pounds)

Chemical	1988			1990			1991		
	All Industries	Refineries	Percent	All Industries	Refineries	Percent	All Industries	Refineries	Percent
Ammonia	340,197,233	47,732,276	12.6%	630,855,392	47,795,152	7.6%	593,713,445	32,778,295	5.5%
Methanol	454,644,479	3,392,976	0.7	429,151,874	2,055,854	0.5	410,187,557	770,962	0.2
Hydrochloric acid	589,486,979	223,567	0.0	336,120,638	238,185	0.1	352,701,658	290,328	0.1
Toluene	359,773,795	12,127,540	3.4	285,316,678	11,195,304	3.9	271,757,898	12,605,973	4.6
Sulfuric acid	362,778,699	532,347	0.1	267,182,375	236,009	0.1	223,500,172	1,380,621	0.6
Acetone	262,021,363	311,820	0.1	231,822,639	380,319	0.2	193,755,190	364,046	0.2
Phosphoric acid	199,821,636	1,344,518	0.7	150,487,283	922,136	0.6	173,046,391	312,350	0.2
Zinc compounds	206,940,719	495,135	0.2	197,254,468	379,750	0.2	172,307,241	280,598	0.2
Xylenes (mixed isomers)	208,135,926	10,147,869	4.9	171,709,725	8,640,024	5.0	166,677,780	7,357,134	5.0
1,1,1-Trichloroethane	196,870,923	160,729	0.1	177,224,241	180,855	0.1	145,996,101	189,063	0.1
Methyl ethyl ketone	166,131,653	6,376,212	3.8	149,956,921	3,807,123	2.5	114,870,964	5,814,644	5.1
Manganese compounds	116,706,077	132,672	0.1	123,816,269	91,791	0.1	99,602,278	74,363	0.1
Ammonium nitrate (solution)	105,116,630	250	0.0	63,308,823	66	0.0	96,783,930	66	0.0
Dichloromethane	154,499,772	940	0.0	111,783,192	250	0.0	94,786,380	15,255	0.0
Carbon disulfide	124,582,198	7,749	0.0	98,837,776	44,019	0.0	89,929,884	49,020	0.1
Chlorine	148,428,258	541,024	0.4	108,337,375	310,710	0.3	79,961,013	527,779	0.7
Ammonium sulfate (solution)	798,851,602	1,338,550	0.2	84,498,497	168,566	0.2	66,772,523	45,010	0.1
Glycol ethers	65,980,305	6,633	0.0	67,639,842	47,907	0.1	58,761,506	34,190	0.1
Copper compounds	62,161,346	133,368	0.2	105,316,790	55,839	0.1	56,030,115	65,828	0.1
Nitric acid	85,836,618	250	0.0	70,544,280	47	0.0	51,732,983	47	0.0
Ethylene glycol	60,511,676	298,408	0.5	48,234,784	286,535	0.6	43,376,834	239,681	0.6
N-butyl alcohol	53,459,483	7,310	0.0	47,535,284	14,231	0.0	40,348,015	90,398	0.2
Chromium compounds	48,203,947	762,934	1.6	43,616,865	534,128	1.2	40,163,165	436,469	1.1
Trichloroethylene	60,296,110	1,420	0.0	42,652,998	5,510	0.0	38,001,222	4,445	0.0
Freon 113	76,423,267	770	0.0	50,120,096	1,025	0.0	37,384,058	0	0.0
Subtotal	5,347,860,714	86,077,267	1.6%	4,093,325,105	77,391,335	1.9%	3,692,148,303	63,726,565	1.7%

After ammonia, refineries released more toluene than any other chemical (12.6 million pounds or 4.6 percent of all toluene releases from U.S. industries in 1991). Next were xylenes (7.4 million pounds or 5.0 percent of the 1991 total) and methyl ethyl ketone (5.8 million pounds or 5.1 percent of the 1991 total).

table 5

REFINERY RELEASES AND TRANSFERS OF
TOP-25 TRI CHEMICALS BY CATEGORY, 1991
(in pounds)

Chemical	Air Releases	Water Releases	Land Releases	Underground Injection	Off-site Transfers	Total
Ammonia	7,920,581	3,093,321	26,514	21,613,500	214,379	32,778,295
Methanol	483,051	19,990	2,419	213,006	51,696	770,962
Hydrochloric acid	285,618	0	4,710	0	0	290,328
Toluene	12,306,606	16,230	48,292	105,002	129,843	12,689,973
Sulfuric acid	1,316,401	2,612	33,165	0	28,443	1,380,646
Acetone	345,956	2,000	5,930	9,796	364	364,046
Phosphoric acid	2,616	5	94,400	0	215,329	312,350
Zinc compounds	28,607	39,896	15,283	38	196,774	280,598
Xylenes (mixed isomers)	7,032,001	16,356	102,543	35,353	170,801	7,357,134
1,1,1-Trichloroethane	187,178	180	60	0	1,645	189,063
Methyl ethyl ketone	5,769,665	5,807	2,276	36,080	896	5,814,644
Manganese compounds	3,607	8,278	62,450	0	28	74,363
Ammonium nitrate (solution)	66	0	0	0	0	66
Dichloromethane	15,255	0	0	0	0	15,255
Carbon disulfide	49,020	0	0	0	0	49,020
Chlorine	489,187	22,786	655	15,151	0	527,779
Ammonium sulfate (solution)	10	45,000	0	0	0	45,010
Glycol ethers	34,183	5	2	0	0	34,190
Copper compounds	2,242	3,018	693	0	59,875	65,828
Nitric acid	47	0	0	0	0	47
Ethylene glycol	61,687	33,939	135,113	8,545	397	239,681
N-butyl alcohol	90,398	0	0	0	0	90,398
Chromium compounds	96,243	19,239	55,771	6	265,210	436,469
Trichloroethylene	4,445	0	0	0	0	4,445
Freon 113	0	0	0	0	0	0
Subtotal	36,524,670	3,238,662	590,276	22,037,197	1,335,760	63,726,565
All other chemicals	27,939,625	427,477	849,395	1,684,638	3,732,270	34,633,405
Grand total	64,464,295	3,666,139	1,439,671	23,721,835	5,068,030	98,359,970

Top-25 TRI carcinogens. Carcinogens are a relatively small share of TRI releases—under 10 percent—with 25 chemicals accounting for 98 percent of the volume. In 1991, petroleum refineries produced 2.5 percent of this subset of releases (see Table 6). Their most common carcinogenic releases were benzene (6 million pounds or 28.6 percent of all benzene releases from U.S. industries in 1991), nickel (0.5 million pounds or 7.9 percent of the 1991 total), asbestos (0.5 million pounds or 7.6 percent of the 1991 total), and 1,3-butadiene (0.3 million pounds or 8.3 percent of the 1991 total).

table 6

RELEASES AND TRANSFERS OF
TOP-25 CARCINOGENS: 1988 & 1990-1991*
(in pounds)

Chemical	1988			1990			1991		
	All Industries	Refineries	Percent	All Industries	Refineries	Percent	All Industries	Refineries	Percent
Dichloroethylene	154,499,772	940	0.0%	111,783,192	250	0.0%	94,786,380	15,255	0.0%
Styrene	42,674,004	28,488	0.1	41,944,574	11,635	0.0	34,021,849	19,956	0.1
Formaldehyde	30,005,282	29,960	0.1	29,580,582	198,243	0.7	23,214,254	171,496	0.7
Chloroform	28,864,093	0	0.0	25,803,925	0	0.0	22,576,422	405	0.0
Benzene	35,693,573	5,417,999	15.2	29,494,454	6,344,812	21.5	20,860,044	5,960,044	28.6
Tetrachloroethylene	42,078,992	729	0.0	27,314,300	683	0.0	20,797,397	1,751	0.0
Lead	21,647,004	198,666	0.9	18,045,405	19,863	0.1	11,337,457	41,536	0.4
Acetaldehyde	9,495,771	0	0.0	9,593,355	0	0.0	9,927,665	1,215	0.0
1,2-Dichloroethane	9,521,584	12,950	0.1	10,130,608	74,827	0.7	9,787,339	17,557	0.2
Acrylonitrile	10,820,701	0	0.0	9,283,784	0	0.0	9,290,398	0	0.0
Chromium	27,599,626	291,002	1.1	23,086,691	440,083	1.9	8,713,880	40,471	0.5
Nickel compounds	9,554,891	0	0.0	10,295,690	0	0.0	6,898,629	0	0.0
Asbestos	15,426,829	995,665	6.5	9,497,692	2,425,620	25.5	6,168,010	467,500	7.6
Nickel	11,972,421	788,911	6.6	11,707,996	422,741	3.6	5,988,929	474,648	7.9
Acrylamide	2,353,479	0	0.0	4,372,190	0	0.0	4,805,182	0	0.0
Cresols	0	0	0.0	0	0	0.0	4,389,494	0	0.0
1,3-Butadiene	7,826,092	264,897	3.4	5,458,128	364,749	6.7	4,113,704	341,101	8.3
Carbon tetrachloride	5,260,610	29,329	0.6	2,900,744	52,427	1.8	2,575,457	46,302	1.8
Polychlorinated biphenyls	5,825,819	9,402	0.2	2,677,105	0	0.0	2,432,787	3,440	0.1
Di-(2-ethylhexyl) phthalate	3,659,801	250	0.0	2,974,543	0	0.0	2,408,030	0	0.0
Ethylene oxide	5,189,165	5,200	0.1	2,799,392	130,600	4.7	1,987,683	129,000	6.5
1,4-Dioxin	1,242,039	0	0.0	1,186,539	17	0.0	1,909,790	0	0.0
Epichlorohydrin	1,305,247	0	0.0	1,252,204	0	0.0	1,400,813	0	0.0
Toluene-2,4-dichloroquinone	397,272	0	0.0	148,346	30	0.0	1,374,011	29	0.0
Propylene oxide	4,915,203	0	0.0	1,863,570	0	0.0	1,197,098	0	0.0
Subtotal	487,829,178	8,074,388	1.7	393,195,009	10,486,580	2.7	312,962,702	7,731,706	2.5
All other carcinogens	10,432,034	282,352	2.7	5,450,224	406,382	7.5	5,902,024	187,556	3.2
Grand total	498,262,112	8,356,740	1.7%	398,645,233	10,892,962	2.7%	318,864,726	7,919,262	2.5%

*Totals and composition of list current as of 1991. At EPA's direction, arsenic, cadmium, and chromium compounds are not included because only a few forms of these chemicals are considered carcinogenic.

For U.S. industry as a whole, releases of TRI carcinogens dropped each year between 1988 and 1991, declining by nearly 36 percent over the period. In contrast, refineries' releases of TRI carcinogens rose and then fell, declining by 5 percent over the period (see Figure 3).

The increase in refineries' releases in 1990, and the decrease in 1991, were chiefly a result of the removal of asbestos that had been used to insulate pipes. Refineries disposed of the asbestos they removed in accordance with EPA regulations; none of it entered either the air or water (see Table 7).

table 7

REFINERY RELEASES AND TRANSFERS OF
TOP-25 TRI CARCINOGENS BY CATEGORY: 1991
(in pounds)

Chemical	Air Releases	Water Releases	Land Releases	Underground Injection	Off-site Transfers	Total
Dichloromethane	15,255	0	0	0	0	15,255
Styrene	19,496	383	0	0	77	19,956
Formaldehyde	169,324	1,970	0	0	202	171,496
Chloroform	405	0	0	0	0	405
Benzene	5,611,824	9,989	91,833	108,390	138,008	5,960,044
Tetrachloroethylene	1,751	0	0	0	0	1,751
Lead	546	203	300	0	40,487	41,536
Acetaldehyde	1,215	0	0	0	0	1,215
1,2-Dichloroethane	16,457	96	1	340	663	17,557
Acrylonitrile	0	0	0	0	0	0
Chromium	10,880	2,130	470	0	26,991	40,471
Nickel compounds	0	0	0	0	0	0
Asbestos	0	0	200,000	0	267,500	467,500
Nickel	10,190	12,703	27,128	53	424,574	474,648
Acrylamide	0	0	0	0	0	0
Crocoate	0	0	0	0	0	0
1,3-Butadiene	333,526	4,573	0	0	3,002	341,101
Carbon tetrachloride	45,272	597	5	5	423	46,302
Polychlorinated biphenyls	0	0	0	0	3,440	3,440
Di-(2-ethylhexyl) phthalate	0	0	0	0	0	0
Ethylene oxide	129,000	0	0	0	0	129,000
1,4-Dioxane	0	0	0	0	0	0
Epichlorohydrin	0	0	0	0	0	0
Toluene-2,4-diisocyanate	29	0	0	0	0	29
Propylene oxide	0	0	0	0	0	0
Subtotal	6,365,170	32,644	319,737	108,788	905,367	7,731,706
All other carcinogens	13,628	2,809	7,698	275	163,146	187,556
Grand total	6,378,798	35,453	327,435	109,063	1,068,513	7,919,262

Waste management and pollution prevention. The 1990 Pollution Prevention Act requires EPA to use the TRI to collect additional information on how manufacturing plants manage wastes and other residual materials. Because EPA has not provided guidance on these reporting requirements, each company interprets them as it believes best. As a result, the data vary widely even among comparable facilities.

Nonetheless, an overall picture is emerging. The data EPA has released thus far show that more than 60 percent of the by-products of the refining process are recycled (see Table 8).

"33/50" program. EPA's voluntary 33/50 program—so-called because it aimed to reduce emissions of 17 chemicals 33 percent by 1992 and 50 percent by 1995—includes a number of large petroleum companies committed to the final goal (see Table 9).

From 1988 to 1991, refineries reduced their releases of 33/50 chemicals by 10 percent (see Figure 4). Over the same period, U.S. industry as a whole reduced releases of these chemicals by 34 percent.

METHODOLOGY

Several factors determine whether a particular chemical is included in the TRI: how much of the chemical is produced and used, how common the chemical is in the environment, and how toxic the chemical is. Scientific judgment and regulatory status also play a role. EPA stresses that reporting releases is a matter of complying with the law, not an indication of failure to meet pollution control regulations.

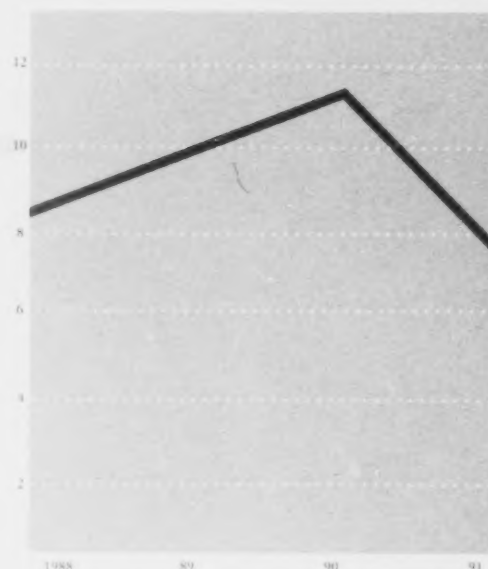
Manufacturing plants report their chemical releases to EPA on "Form R," which must be filed each July 1 for the year before. In 1991, 181 refineries filed this form.

EPA provides access to TRI data through an on-line database called TOXNET, part of the National Library of Medicine's computer system. It is updated periodically to reflect receipt of additional information, improvements in estimation techniques, and to correct data entry errors. Each year, EPA also publishes a written annual report on the TRI.

Aggregating data. Refineries provide most of the petroleum industry's data on chemical releases. The TRI does not include other petroleum manufacturing facilities—for example, plants that make lubricants, fuel additives, and packaging materials. It also does not include exploration and production, transportation, and marketing facilities such as service stations and bulk terminals.

EPA uses the Standard Industrial Classification system, developed by the federal government's Office of Management and Budget, to categorize TRI data. Each industry has a four-digit SIC code (the first

figure 3
**REFINERY RELEASES AND TRANSFERS OF TRI
CARCINOGENS: 1988-1991**
(in millions of pounds)



Refineries' releases and transfers of carcinogens declined by 5 percent between 1988 and 1991.

table 8
**TRI WASTE MANAGEMENT AND POLLUTION
PREVENTION PRACTICES: 1991**
(in pounds)

Method	Weight	Percent
On-site:		
Recycling	1,531,968,714	39.8%
Treatment	596,382,976	15.5
Disposal	722,319,958	18.3
Subtotal	2,850,671,648	74.1
Off-site:		
Recycling	865,490,791	22.5
Treatment	118,191,724	3.0
Disposal	15,059,578	0.4
Subtotal	998,742,093	25.9
Grand total	3,849,413,741	100.0%

two digits represent the kind of activity). The full SIC code for petroleum refineries is 2911, a category that also includes manufacturers of paving and roofing products.

EPA allows facilities to file under more than one SIC code, so refineries that also produce petrochemicals may report some releases under SIC 29 and others under SIC 28. In addition, companies with refining and petrochemical operations on the same site may report their releases under a single SIC code or a separate category called "multiple industries." This report is limited to TRI data on petroleum refineries operating in the continental United States. It includes all releases from refineries (regardless of the SIC code used to report them to EPA) and excludes releases from sources other than refineries.

Variations in API and EPA data. The SIC code for petroleum refining includes releases from other sources—just as some refinery releases appear under "multiple industry" and other SIC codes. To address this problem, API compared EPA's list of refineries with its own records, U.S. Department of Energy records, and lists of refineries in the *Oil & Gas Journal* and the *Penn Well Directory*.

table 9

REFINERY RELEASES AND TRANSFERS OF
"33/50" TRI CHEMICALS: 1988 & 1990-1991
(In pounds)

Chemical	1988			1990			1991		
	All industries	Refineries	Percent	All industries	Refineries	Percent	All industries	Refineries	Percent
Toluene	359,773,795	12,127,540	3.4%	285,316,678	11,195,304	3.9%	223,500,172	12,605,973	5.6%
Xylenes (mixed isomers)	208,135,926	10,147,869	4.9	171,709,725	8,640,024	5.0	146,677,780	7,357,134	5.0
1,1,1-Trichloroethane	196,870,923	160,729	0.1	177,224,241	180,855	0.1	145,996,101	189,063	0.1
Methyl ethyl ketone	166,131,653	6,376,212	3.8	149,956,921	3,807,123	2.5	114,870,964	5,814,644	5.1
Dichloromethane	154,499,772	940	0.0	111,783,192	250	0.0	94,786,380	15,255	0.0
Chromium and compounds	75,803,573	1,053,936	1.4	66,703,556	974,211	1.5	48,877,045	476,940	1.0
Lead and compounds	60,806,779	462,194	0.8	77,925,377	457,446	0.6	39,750,743	222,147	0.6
Trichloroethylene	60,296,110	1,420	0.0	42,652,998	5,510	0.0	38,001,222	4,445	0.0
Methyl isobutyl ketone	44,369,306	276,410	0.6	33,647,385	184,135	0.6	30,795,824	127,565	0.4
Chloroform	28,864,093	0	0.0	25,803,925	0	0.0	22,576,422	405	0.0
Benzene	35,693,573	5,417,999	15.2	29,494,454	6,344,812	21.5	20,860,044	5,960,044	28.6
Tetrachloroethylene	42,078,992	729	0.0	27,314,300	683	0.0	20,797,397	1,751	0.0
Nickel and compounds	21,527,312	788,911	3.7	22,003,686	422,741	1.9	12,941,558	474,648	3.7
Cyanide compounds	11,886,672	250	0.0	8,704,880	6	0.0	7,846,044	0	0.0
Carbon tetrachloride	5,260,618	2,000	0.0	2,900,744	52,427	1.8	2,575,457	46,302	1.8
Cadmium and compounds	1,830,212	0	0.0	1,859,484	67	0.0	2,046,983	29	0.0
Mercury and compounds	318,381	750	0.2	242,207	98	0.0	219,774	224	0.1
Total	1,474,147,690	36,817,889	2.5%	1,235,243,753	32,265,692	2.6%	973,119,910	33,296,569	3.4%

In 1990, EPA erroneously identified 12 facilities as refineries, categorized six refineries as something other than refineries, and omitted one refinery altogether. The 1991 data were more accurate—perhaps because more reports were submitted in electronic form, which reduces key-punching errors.

As a result of these corrections, in 1991 API attributed more releases to refineries than EPA did: 98,359,970 pounds versus 85,999,527 pounds.

Implications. Since the TRI data are not strictly comparable from one year to the next, caution must be used when performing analyses, making comparisons, and interpreting results.

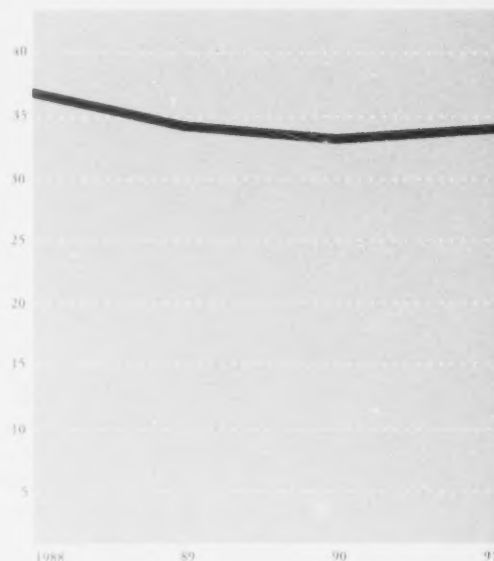
Methods of estimating certain releases—in particular, fugitive emissions—have changed over the years. The reporting threshold, the mix of companies, and the composition of the TRI have changed as well—for example, in 1990 EPA added nine chemicals and dropped eight; in 1991 EPA added seven chemicals and dropped eleven.

Methods of categorizing chemicals also differ from year to year. Reporting two chemicals together—or enlarging a group of chemicals to include a related compound—can make it appear that some releases are increasing and others decreasing. In actuality, they are just reported differently.

Changes in operations further complicate trend analysis. Refinery releases fluctuate with the level of activity and the composition of crude oil. Opening or closing refineries and changes in environmental regulations can introduce distortions as well.

Unless otherwise indicated, the 1990 refinery data are current as of November 1992, the 1991 refinery data are current as of October 1993, and the 1988 refinery data are current as of February 1992. The 1988, 1990, and 1991 data for U.S. industry as a whole are current as of May 1993.

figure 4
**REFINERY RELEASES AND TRANSFERS OF
"33/50" TRI CHEMICALS: 1988-1991**
(in millions of pounds)



Refineries' releases and transfers of chemicals included in the 33/50 program declined by 10 percent between 1988 and 1991.

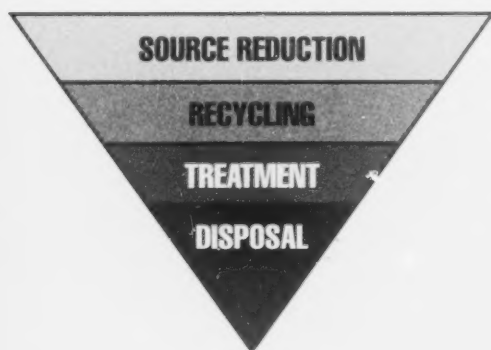
refinery residuals



This analysis of wastes and other by-products of petroleum refining between 1987 and 1991 is based on an annual API survey. The survey covers 30 types of materials and is sent to all operating U.S. refineries; about two-thirds responded in 1991, representing 73 percent of U.S. refining capacity.

Based on responses to the survey, API has estimated the volume of wastes and other residual materials for the industry as a whole. API also uses the survey to gather information about how refineries recycle, treat, and dispose of residuals—and their efforts to generate less waste by reducing it at the source.

The survey uses the waste management hierarchy, referenced in the 1990 Pollution Prevention Act, as an organizing tool. In accord with this conceptual framework, API characterizes some trends as improvements—for example, reducing waste at the source and treating or recycling materials instead of discarding them.



The waste management hierarchy has four levels: source reduction, recycling, treatment, and disposal. In theory, source reduction is most desirable because it prevents the creation of waste. Recycling is next best because it, too, prevents waste and conserves resources. Treatment makes unavoidable wastes less bulky or less hazardous. Disposal is the route of last resort.

The reality is more complicated. Source reduction and recycling may be preferable from purely a management perspective—but are not always feasible for technological or economic reasons.

DEFINITIONS

Disposal. Discarding wastes either on- or off-site—for example, depositing them on land or injecting them underground. For purposes of this report, disposal does not include wastewaters sent to municipal sewer plants or discharges into bodies of water permitted under the National Pollutant Discharge Elimination System (NPDES).

Hazardous wastes. Wastes the Resource Conservation and Recovery Act classifies as hazardous. May be listed as such under the law—for example, API separator sludge—or exhibit hazardous characteristics (corrosivity, ignitability, reactivity or toxicity).

Land treatment. Using soil microbes to break down wastes in accord with Resource Conservation and Recovery Act regulations. Also known as land farming. Because RCRA restricts disposal of hazardous wastes on land, this report combines data on land treatment and data on other methods of disposing of hazardous wastes. Elsewhere in the report, data on land treatment is presented with data on other methods of treatment.

Recycling. Recovering materials from wastes for the same or another use—for example, catalysts and metals. Includes regeneration—restoring the operative properties of solvents, resins, and other materials so they can be reused.

Refinery residuals. Wastes and other by-products of petroleum refining: oil, water, and solids such as particles of soil and catalysts. Includes hazardous wastes that must be handled in accord with Resource Conservation and Recovery Act regulations, as well as valuable materials that can be recycled or otherwise reused in industrial processes.

Source reduction. Reducing or eliminating waste by preventing it in the first place—at the source. Accomplished by changing processes, feedstocks or increasing efficiency.

Treatment. Using physical, chemical or biological means to reduce the volume or toxicity of wastes. Methods include biodegradation, incineration, stabilization, and fixation.

Wet ton. 2,000 pounds. The word “wet” is included to indicate that the material contains liquids.

table 1

ESTIMATED RESIDUALS BY
TYPE OF MATERIAL: 1987-1991
(in thousands of wet tons)

Material	1987	1988	1989	1990	1991
Spent caustics	675	656	715	889	909
Biomass	757	785	642	782	855
Contaminated soils and solids	165	240	512	920	809
Dissolved air flotation*	652	655	496	553	406
Inorganic materials (unspecified)	325	214	440	451	397
Pond sediments	337	266	313	1,017	372
Other materials (unspecified)	203	412	325	352	339
API separator sludge*	400	355	419	251	210
Field cracking catalysts or equivalent	173	193	182	198	204
Primary sludge—physical/chemical separation*	—	—	—	—	177
Slip oil emulsion solids*	208	224	272	291	165
Residual cake, carbon, and charcoal	43	67	129	92	138
Residual amines	13	14	51	75	156
Primary sludge—gravitational separation*	—	—	—	—	130
Unleaded tank bottoms	216	129	161	194	109
Spent acids	126	149	8	336	88
Oil contaminated waters	28	36	29	8	67
High pH and low pH waters	144	138	91	105	54
Oily sludges and organic materials (unspecified)	39	61	47	53	54
Contaminated soils (unspecified)	82	68	53	69	37
Hydroprocessing catalysts	40	36	36	31	32
Spent Stratford solution	35	48	42	29	25
Spent catalysts (unspecified)	33	37	33	39	23
Residual oils and spent solvents	4	7	31	115	21
Leachate from treatment, storage or disposal*	—	—	—	—	20
Residual sulfur	17	22	52	35	19
Spent sulfite solution	42	40	8	1	9
Heat exchanger bundle cleaning sludge*	3	5	2	13	3
Loaded tank bottoms*	9	8	4	3	1
Separator sludges (unspecified)**	79	104	115	97	—
Subtotal	4,848	4,969	5,208	6,999	5,809
Aqueous wastes (unspecified)	11,296	11,076	11,100	11,106	9,040
Total generated	16,144	16,045	16,308	18,105	14,849
Treatment additives	55	72	35	88	42
Net amount from storage	139	45	-41	47	-43
Total managed	16,338	16,162	16,302	18,240	14,848

* Classified as a hazardous waste under the Resource Conservation and Recovery Act.

** Counted as primary sludges (gravitational and chemical/physical) starting in 1991.

RESULTS

U.S. petroleum refineries managed an estimated 14.8 million wet tons of wastes and other residual materials in 1991—3.4 million less than the year before and the lowest amount since API started conducting its survey (see Table 1).

After remaining relatively flat from 1987 through 1989, residuals rose sharply in 1990. That year, the U.S. Environmental Protection Agency published final regulations for handling wastes classified as hazardous under the Resource Conservation and Recovery Act. In response, many refineries closed ponds and impoundments, causing a temporary increase in contaminated soils, solids, and pond sediments. Residual oils, spent solvents, and spent acids rose as well.

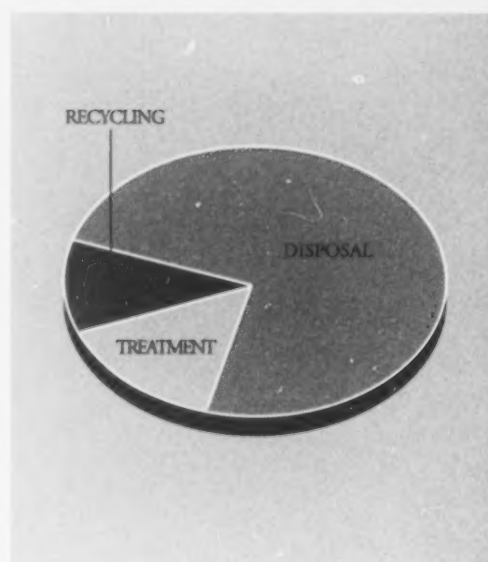
In 1991, each of these waste streams dropped—as did the total amount of refinery residuals. Thus, the increase the year before was a harbinger of environmental progress—a reflection of refineries' quick response to new federal regulations.

Composition of residuals. Unspecified aqueous wastes were about two-thirds of the refinery residuals generated between 1987 and 1991. Virtually all of these wastes came from a small number of refineries—five at most—which disposed of them by injecting them underground. From a high of 11.3 million tons in 1987—70 percent of all residuals generated that year—unspecified aqueous wastes declined to 9 million tons or 61 percent of the residuals generated in 1991.

Disposal is the main means of dealing with refinery residuals, followed by treatment and recycling (see Figure 1). As a share of total weight, recycling went up, disposal went down, and treatment remained about the same between 1987 and 1991 (see Table 2).

figure 1

RESIDUALS BY MANAGEMENT METHOD: 1991
(percent of total weight)



Refineries dispose of 74 percent of their residual materials, treat 15 percent, and recycle 11 percent.

table 2

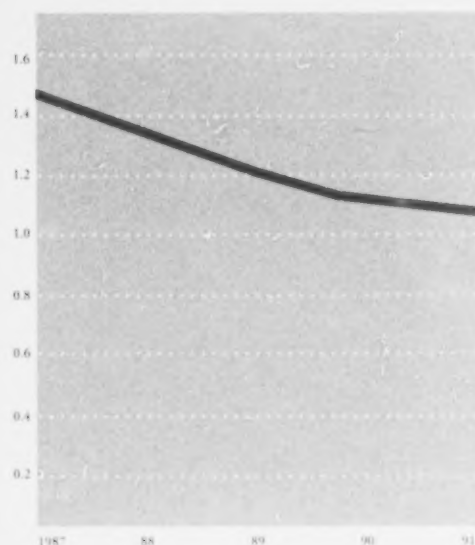
ESTIMATED RESIDUALS BY
MANAGEMENT METHOD: 1987-1991
(in thousands of wet tons)

Method	1987		1988		1989		1990		1991	
	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Disposal:										
Aqueous wastes (unspecified)	11,290	69%	11,067	69%	11,091	68%	11,094	61%	9,040	61%
Other wastes and residuals	1,541	9	1,638	10	1,619	10	2,231	12	1,973	13
Treatment:										
Land treatment	850	5	832	5	709	5	1,148	7	538	4
Other methods	1,582	10	1,446	9	1,511	9	1,874	10	1,707	11
Recycling	1,075	7	1,179	7	1,372	8	1,893	10	1,590	11
Total	16,338	100%	16,162	100%	16,302	100%	18,240	100%	14,848	100%

figure 2

HAZARDOUS WASTES: 1987-1991

(in millions of tons)



Hazardous wastes declined from 1.4 million tons in 1987 to 1.1 million tons in 1991.

Hazardous wastes. Largely sludges, hazardous wastes are a relatively small share of the total—8 percent in 1991. That year, refineries managed 1.1 million tons of hazardous wastes (see Table 3), a drop from the high of 1.4 million tons in 1987 (see Figure 2).

In 1991, EPA added three refinery residuals to the five already listed as hazardous wastes: primary sludge—gravitational separation; primary sludge—chemical/physical separation; and leachate from treating, storing or disposing of hazardous wastes. The sludges were already part of API's survey (though categorized differently); API captured data on leachate for the first time in 1991.

Like API's survey, the following discussion uses the waste management hierarchy as an organizing tool:

Source reduction and related efforts. In 1991, the refineries that participated in API's survey reported that source reduction and related efforts avoided some 751,000 tons of waste. Nearly half of this was hazardous waste.

table 3

ESTIMATED HAZARDOUS WASTES

BY MANAGEMENT METHOD: 1987-1991

(in thousands of wet tons)

Method	1987		1988		1989		1990		1991	
	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Treatment	580	40%	524	40%	582	48%	543	48%	694	62%
Recycling	210	15	258	20	309	25	308	27	293	26
Disposal*	652	45	536	40	324	27	284	25	133	12
Total	1,442	100%	1,318	100%	1,215	100%	1,135	100%	1,120	100%

*For purposes of classifying data on hazardous wastes, land treatment is counted as disposal; everywhere else in this report, it is counted as treatment.

table 4

RECYCLING BY TECHNIQUE: 1987-1991

(in thousands of wet tons)

Technique	1987		1988		1989		1990		1991	
	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Reclamation and regeneration	447	42%	434	37%	600	44%	872	46%	772	49%
Reuse in crude unit	69	6	85	7	124	9	174	9	217	14
Reuse in coker	148	14	186	16	231	17	192	10	181	11
Other techniques	411	38	474	40	417	30	655	35	420	26
Total	1,075	100%	1,179	100%	1,372	100%	1,893	100%	1,590	100%

Recycling. The most common means of recycling are reclamation and regeneration. Reclamation involves recovering valuable materials and selling them for reuse in other facilities or industries—generally, catalysts and other metal-bearing materials in small amounts. Regeneration entails restoring the operative properties of materials such as solvents and resins so they can be reused—in the same process or a different process—either within the refinery or elsewhere.

The amount of material refineries recycle rose by 76 percent from 1987 to 1990—going from nearly 1 million to 1.9 million tons—then fell to about 1.6 million tons in 1991 (see Table 4).

table 5

TREATMENT BY TECHNIQUE: 1987-1991

(in thousands of wet tons)

Technique	1987		1988		1989		1990		1991	
	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Wastewater treatment	1,171	48%	1,045	46%	1,177	53%	1,265	42%	1,465	65%
Land treatment	850	35	832	37	709	32	1,148	38	538	24
Incineration	107	4	131	6	143	6	165	6	215	10
Stabilization and fixation	<1	<1	5	<1	4	<1	276	9	3	<1
Other chemical and physical treatment	118	5	148	6	143	7	131	4	2	<1
Other techniques	186	8	117	5	44	2	37	1	22	<1
Total	2,432	100%	2,278	100%	2,220	100%	3,022	100%	2,245	100%

Treatment. Refineries use various means to reduce the volume and toxicity of their wastes. Physical treatment includes the use of filters, centrifuges, evaporation or other means to separate solids and liquids; liquids are then treated further to separate oil and water. Chemical treatment includes the use of emulsion-breaking polymers, incineration, and other forms of thermal destruction. Biological treatment harnesses micro-organisms' metabolic processes to break down organic wastes.

Overall, the amount of treated material remained at about 2.3 million tons from 1987 to 1989, peaked at 3 million tons in 1990, then dropped back to 2.2 million tons in 1991. The amount of incinerated material doubled between 1987 and 1991, going from 4 percent to 10 percent of the total. The amount of material undergoing land treatment rose from about 0.9 million tons in 1987 to more than 1.1 million tons in 1990, then declined to 0.5 million tons in 1991 (see Table 5).

Disposal. Most refineries dispose of wastes by sending them to landfills or impoundments, which handle them in accord with Resource Conservation and Recovery Act regulations and other applicable state and federal laws. In general, contaminated soils, solids, and pond sediments are sent to landfills while oily sludges and biomass are sent to impoundments. In addition, a few refineries inject unspecified aqueous wastes underground.

In all, refineries disposed of some 12.8 million tons of waste each year from 1987 through 1989, 13.3 million tons in 1990, and 11 million tons in 1991 (see Table 6).

METHODOLOGY

Each year since 1987, API has conducted a survey of refineries' waste management and pollution prevention practices. Although the survey is comprehensive—it covers 30 residual materials—it does not include wastewaters sent to municipal sewer plants. It also does not include discharges governed by the National Pollutant Discharge Elimination System, under which the U.S. Environmental Protection Agency issues permits allowing industrial plants to release pollutants into U.S. waters.

The survey asks questions about the refinery's age, size, complexity, and pollution prevention activities. The survey also includes 30 one-page "data sheets" (one for each type of material) that request detailed information about the volume of wastes and other residual materials, and how refineries manage them.

table 6
DISPOSAL BY TECHNIQUE: 1987-1991
(in thousands of wet tons)

Technique	1987		1988		1989		1990		1991	
	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent	Weight	Percent
Underground injection:										
Aqueous wastes (unspecified)	11,289	88%	11,067	87%	11,091	87%	11,089	83%	9,040	82%
Other wastes and residuals	40	<1	31	<1	15	<1	36	<1	35	<1
Landfills	1,070	8	1,199	10	1,375	11	1,889	14	1,703	15
Impoundments	280	2	246	2	113	1	129	1	110	1
Other techniques	152	2	162	1	116	1	182	2	125	2
Total	12,831	100%	12,705	100%	12,710	100%	13,325	100%	11,013	100%

For the 1991 survey—the most recent data included in this report—API sent questionnaires to 183 refineries listed in the U.S. Department of Energy's *1991 Petroleum Supply Annual*. The 113 respondents included 70 refineries that have participated in the survey each year API has conducted it. The average response rate for the period of this report represents 75 percent of U.S. refining capacity (see Table 7).

Estimation. To estimate the amount of waste and other residuals the U.S. refining industry generates as a whole, API used regression analysis with refinery operating capacity as the explanatory variable. Other factors such as refinery age, type, and sewer system were considered, but not used. Combining these factors with operating capacity did not significantly improve the regression model's predictive capability.

Confidence. Standard errors of the estimates were used to construct a margin of error equal to twice the standard error in either direction—corresponding to an approximate 95 percent confidence interval. On the assumption that responses to the survey were accurate, the calculation of standard errors was based on the number of non-responding refineries and the method used to estimate the amount of waste they generated.

For API's estimate of the total amount of waste and residuals U.S. refineries generated, the estimated margin of error was plus or minus 2.0 percent in 1987, plus or minus 1.9 percent in 1988, plus or minus 2.3 percent in 1989, plus or minus 2.4 percent in 1990, and plus or minus 2.1 percent in 1991. Thus, API estimates with 95 percent certainty that U.S. refineries generated between 14.5 million and 15.2 million tons of waste and residuals in 1991.

table 7

SURVEY RESPONSE RATE: 1987-1991

Category	1987	1988	1989	1990	1991
Number of operating refineries	176	176	183	183	183
Number of responding refineries	115	115	117	103	113
Percent of refining population	65%	65%	64%	56%	62%
Percent of refining capacity	80%	80%	74%	70%	73%

oil spills

This analysis of oil spills from 1983 to 1992 is based on U.S. Coast Guard records of spills in navigable U.S. waters: inland waterways such as bays, harbors, rivers, lakes, and sounds; seas up to 12 miles from U.S. shores; and other waters under U.S. jurisdiction, including the oceans up to 200 miles from shore. The report does not cover spills on land.

The Coast Guard's records contained the raw data API needed to analyze the industry's main concerns: the number of petroleum spills, their size, and the frequency and volume of spills from different sources. But the Coast Guard had not organized its records that way. Understandably, it focused on data intrinsic to its own mission such as the number of Coast Guard ships and personnel called to the scene of a spill—the kind of information police gather about traffic accidents.

Beyond that, the Coast Guard's records included spills of oils that are not petroleum-based—for example, vegetable oils. And where the Coast Guard tracks two kinds of spills—from "vessels" (boats and ships) and from "facilities" (everything else)—the petroleum industry needed more detail.

Therefore, before analytical work could begin, API had to retrieve and compile basic data. To improve accuracy, API also refined the data in ways the Coast Guard either recommended or endorsed. These included deleting records of non-petroleum spills, correcting data entry errors, and eliminating double-counting caused by duplicate records of the same spill.

In the course of analyzing the Coast Guard's records, API determined that more than half the spills are from vessels and facilities owned by the U.S. government, the armed forces, other industries, and private citizens—not the companies that comprise the U.S. petroleum industry.

DEFINITIONS

The U.S. Coast Guard tracks spills by source: "vessels" (boats and ships) and "facilities" (everything else). API broke out the data on petroleum spills, grouping together spills from similar sources in the categories defined below. Due to missing or incomplete Coast Guard records, it was impossible to analyze data on specific petroleum industry facilities—for example, refineries.

Airports. Commercial aviation facilities located near bodies of water where petroleum may spill.

Barges. Flat-bottomed boats fitted with tanks for transporting petroleum. Usually pushed or pulled by tugboats.

Freighters. Barges and ships used for transporting non-petroleum products—for example, corn.

LOOP. Louisiana Offshore Oil Port, a man-made deep water port in the Gulf of Mexico.

Natural events. Earthquakes and other natural upheavals that cause spills in oil-producing areas.

Offshore facilities. Drilling platforms and related oil production facilities located in bodies of water.

Offshore vessels. Ships that carry supplies and other materials to and from offshore drilling platforms.

Onshore facilities. Land-based facilities that handle petroleum products—for example, refineries, loading docks, storage tanks, marketing terminals, and drilling platforms.

Other vessels. Boats and ships not primarily engaged in transporting petroleum that nevertheless have oil on board—for example, tugboats, fishing boats, recreational boats, passenger ships, and military ships.

Pipelines. A line of pipes with pumps, valves, and control devices used to convey petroleum products from one place to another—from offshore oil wells to land, from onshore wells to refineries, and from refineries to marketing terminals.

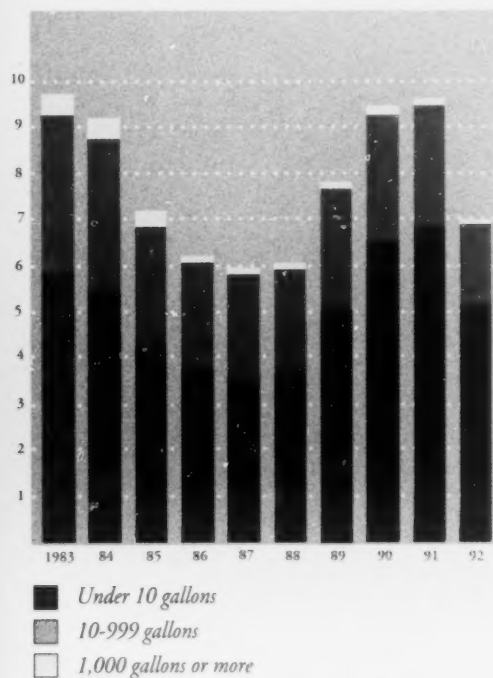
Railroads. Railroad cars equipped with tanks for carrying petroleum products.

Tankers. Large ocean-going ships fitted with tanks for carrying liquid cargo such as crude oil, gasoline, and other petroleum-based fuels.

Tank trucks. Trucks equipped with tanks for carrying liquid petroleum products such as gasoline.

figure 1

TOTAL NUMBER OF OIL SPILLS: 1983-1992
(in thousands)



After rising for several years, the number of oil spills dropped sharply in 1992.

Unknown. Vessels and facilities that are identified as sources of spills but cannot be defined further due to missing or incomplete Coast Guard records.

Vehicles. Starting in 1992, all types of land vehicles, including tank trucks. Before 1992, all land vehicles except tank trucks.

RESULTS

Over the decade 1983 to 1992, nearly 78,000 spills of crude oil and petroleum products occurred in U.S. waters (see Figure 1). Those spills totalled 64.9 million gallons—or 1.5 million barrels (each barrel equals 42 gallons).

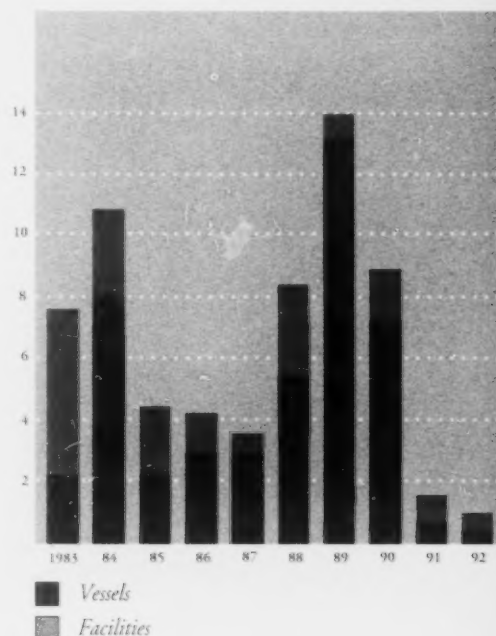
Two broad trends are evident in the latter part of the period: more small spills (possibly a function of better reporting) and fewer large spills. The result is a dramatic drop in the volume spilled—from nearly 14 million gallons in 1989 to about 1 million gallons in 1992 (see Figure 2). Overall, nearly three-fourths of the oil spilled while moving it from one place to another—by tanker, barge, pipeline, railroad or tank truck (see Figure 3).

Between 1983 and 1992, more than 30 percent of the spills occurred in coastal waters within 12 miles of U.S. shores; another 42 percent occurred in inland bodies of water. The rest occurred in other bodies of water under U.S. jurisdiction, including the oceans up to 200 miles from shore.

The petroleum industry neither owns nor operates many of the vessels and facilities where spills originate. Although the Coast Guard stopped tracking facility ownership in 1992, its records show that roughly 60 percent of the spills between 1983 and 1991 were from vessels or facilities owned by the U.S. government, the armed forces, other industries, and private citizens. The other 40 percent of the spills were from vessels, facilities, and vehicles owned or operated by the petroleum industry.

figure 2

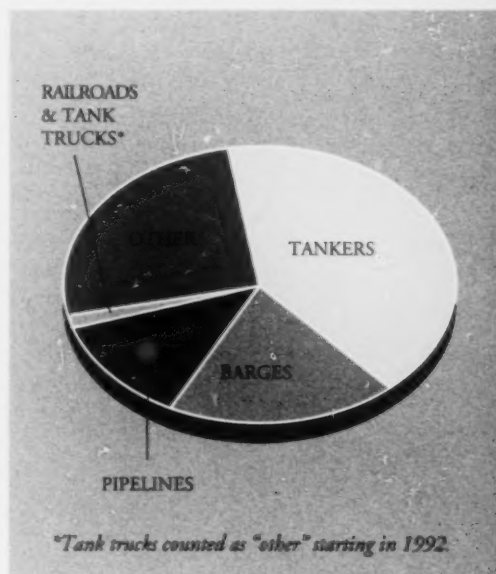
TOTAL VOLUME OF OIL SPILLS: 1983-1992
(in millions of gallons)



Volume has declined dramatically with the drop in large oil spills.

figure 3

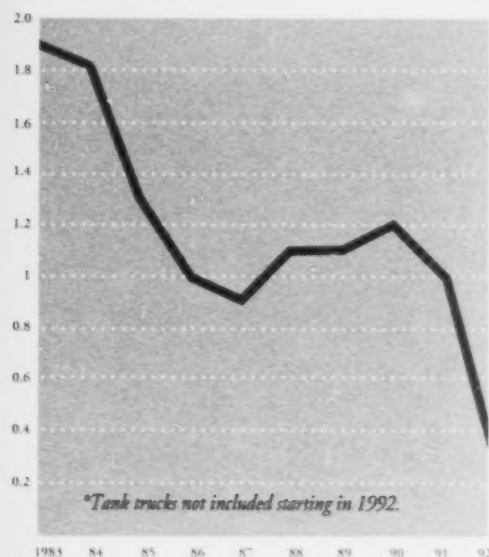
SOURCES OF OIL SPILLS: 1983-1992
(percent of total volume)



By volume, nearly three-fourths of the oil spills were from tankers, barges, and pipelines.

figure 4

NUMBER OF PETROLEUM INDUSTRY SPILLS RELATED
TO TRANSPORTATION: 1983-1992*
(In thousands)



Spills attributed to petroleum industry transportation declined throughout the period.

The number of spills that occurred while transporting petroleum declined sharply during the period (see Figure 4). The industry averaged 1,376 spills per year from 1983 to 1987 and 947 spills per year from 1988 to 1992. The drop paralleled the decline in the distance petroleum traveled: from 606 billion miles per year between 1983 and 1987 to 542 billion miles per year between 1988 and 1992.

While the Coast Guard's records did not show the type of vessel involved in one-third of the cases—perhaps it was not reported or the Coast Guard received incomplete information—most such spills were small (95 percent were under 2 barrels). It is therefore unlikely that they involved groundings or collisions of tankers or barges.

The Coast Guard's records also failed to indicate the type of facility in about 38 percent of the cases. Again, most such spills were small (75 percent were under 10 gallons).

Number and size of spills. The total number of spills declined each year from 1983 to 1987, when it reached a low of just under 6,000. The next year, the number of spills rose and climbed to a high of nearly 9,600 in 1991 before dropping back to about 6,900 in 1992 (see Table 1).

While nearly two-thirds of the spills were under 10 gallons, a few unusually large spills inflated the average for the period: 834 gallons. The median of 2 gallons is more descriptive. (By definition, the median is the point that half the spills are above and half are below in size.)

table 1

TOTAL NUMBER OF OIL SPILLS
BY SIZE: 1983-1992

Year	Under 10 gallons	10-999 gallons	1,000-9,999 gallons	10,000-99,999 gallons	100,000+ gallons	Total
1983	5,944	3,363	376	64	15	9,662
1984	5,446	3,273	366	74	16	9,175
1985	4,210	2,571	311	52	9	7,153
1986	3,737	2,285	128	25	11	6,186
1987	3,544	2,250	128	23	8	5,953
1988	3,626	2,238	125	29	11	6,029
1989*	5,024	2,580	136	37	7	7,784
1990*	6,480	2,720	164	43	11	9,418
1991	6,791	2,620	138	25	3	9,577
1992	5,093	1,772	99	12	3	6,939
Total	49,795	25,672	1,931	384	94	77,876

*Data revised by U.S. Coast Guard.

Spills of 10 gallons or more declined from 1983 to 1988, rose in 1989, and remained steady until 1992, when they dropped by one-third. Though the number of spills of 1,000 gallons or more declined from nearly 5 percent of the 1983 total to about 1 percent of the 1992 total, they accounted for 96 percent of the volume spilled over the 10-year period.

The total amount spilled was about three-thousandths of one percent—0.003 percent—of the 2.5 trillion gallons of petroleum products Americans used between 1983 and 1992.

Volume and source of spills. Between 1983 and 1992, "facility" spills outnumbered "vessel" spills by a considerable margin: 44,500 versus 33,400. But vessels accounted for 70 percent of the volume spilled: 46 million gallons versus 19 million gallons. And in the last two years of the period, the total amount spilled declined dramatically: by more than 82 percent in 1991 and another 37 percent in 1992 (see Table 2).

The "vessel" category includes tankers, barges, and freighters; ships that supply offshore wells; fishing and recreational boats; and military and other waterborne craft. The "facility" category includes land transportation such as railroads and tank trucks; pipelines; the Louisiana Offshore Oil Port; petroleum industry facilities such as refineries, storage tanks, and drilling platforms; airports; and natural events such as earthquakes in oil-producing areas.

table 2
TOTAL VOLUME OF
OIL SPILLS BY SOURCE: 1983-1992
(in thousands of gallons)

Year	Vessels	Facilities	Total
1983	2,236	5,405	7,641
1984	8,093	2,833	10,926
1985	2,276	2,177	4,453
1986	3,001	1,280	4,281
1987	2,993	618	3,611
1988	5,469	2,998	8,467
1989	13,190	798	13,988
1990	7,315	1,623	8,938
1991	747	855	1,602
1992	428	580	1,008
Total	45,748	19,167	64,915

**Data revised by U.S. Coast Guard.*

Vessel spills. Nearly 60 percent of the vessel spills between 1983 and 1992 were small: under 10 gallons. The median size of all vessel spills was 5 gallons, but the average was much higher: 1,369 gallons. A few large tanker spills explain the wide gap between the two numbers (see Table 3).

After declining from 1983 to 1985, the number of vessel spills began rising in 1986. This reflects the growing number of spills from fishing and recreational vessels—operated by people who are not part of the petroleum industry—and may be a function of better reporting rather than more frequent spills.

In contrast, the number of spills of 10,000 gallons or more remained steady from 1985 to 1987, rose from 1988 to 1990, then dropped dramatically in 1991 and 1992. Although the total number of vessel spills rose about 8 percent between 1991 and 1992, nearly 60 percent of the spills were under 10 gallons in size.

table 3

NUMBER OF OIL SPILLS FROM VESSELS
BY SIZE: 1983-1992

Year	Under 10 gallons	10-999 gallons	1,000-9,999 gallons	10,000-99,999 gallons	100,000+ gallons	Total
1983	1,341	1,150	86	19	5	2,601
1984	1,333	1,079	78	21	13	2,524
1985	1,178	952	59	13	7	2,209
1986	1,661	1,260	74	15	8	3,018
1987	1,723	1,228	62	13	7	3,033
1988	1,896	1,299	57	23	7	3,282
1989	2,197	1,440	66	25	5	3,733
1990	2,576	1,533	92	28	7	4,236
1991	2,689	1,446	70	12	1	4,219
1992	3,306	1,215	29	2	1	4,553
Total	19,900	12,602	673	171	62	33,408

*Data revised by U.S. Coast Guard.

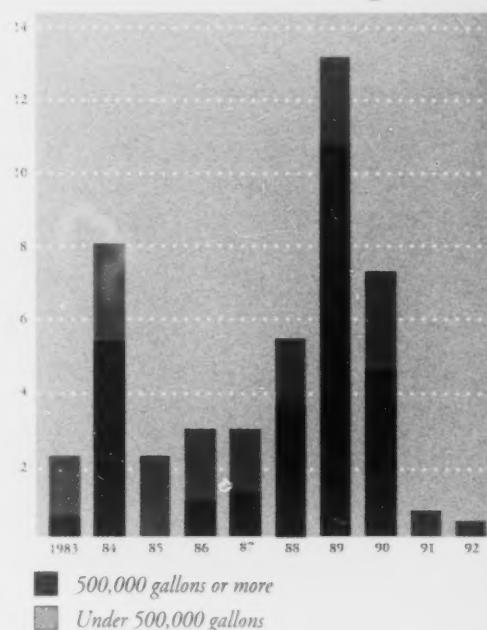
Most of the large spills were from tankers and barges. Between 1983 and 1992, tankers spilled some 26.8 million gallons—almost 59 percent of the total—and barges spilled some 12.5 million gallons—about 27 percent of the total (see Table 4).

The relatively large amounts spilled in 1984, 1989, and 1990 reflect the influence of large tanker spills. The single largest spill—10.8 million gallons in 1989—accounted for over three-fourths of the volume spilled that year. In 1990, a single 3.9 million gallon spill was close to half the total spilled (see Figure 5).

Between 1983 and 1992, tanker and barge spills averaged 1.4 per billion ton miles—that is, 1.4 spills for each billion miles a ton of petroleum traveled. The average declined sharply in the last two years of the period: from 1.8 spills per billion ton miles in 1991 to 0.9 spills per billion ton miles in 1992.

figure 5

VOLUME OF OIL SPILLS FROM VESSELS: 1983-1992
(in millions of gallons)



The spikes in volume reflect unusually large tanker spills during those years.

table 4

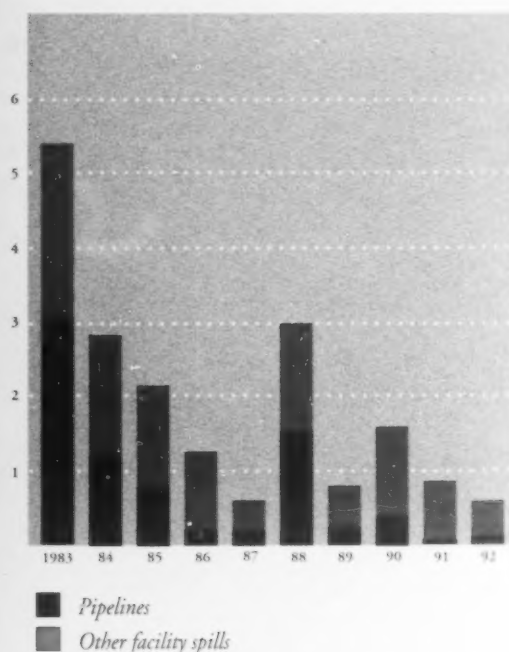
VOLUME OF OIL SPILLS FROM
VESSELS BY SOURCE: 1983-1992
(in thousands of gallons)

Year	Freighters	Barges	Tankers	Offshore Vessels	Other Vessels	Unknown	Total
1983	251	1,524	185	7	246	23	2,236
1984	1,483	1,463	4,638	39	446	24	8,093
1985	178	1,053	727	2	254	62	2,276
1986	44	1,573	1,090	2	134	158	3,001
1987	540	574	1,497	3	329	50	2,993
1988	90	3,247	1,816	5	238	73	5,469
1989	326	824	11,572	35	390	43	13,190
1990	81	1,840	5,070	12	251	61	7,315
1991	56	270	97	11	261	52	747
1992	11	175	116	4	66	56	428
Total	3,060	12,543	26,808	120	2,615	602	45,748

*Data revised by U.S. Coast Guard.

figure 6

VOLUME OF OIL SPILLS FROM FACILITIES: 1983-1992
(in millions of gallons)



The volume of facility spills dropped in the first half of the decade, rose and then dropped again.

Facility spills. Like most vessel spills, most facility spills are small. More than two-thirds of the facility spills between 1983 and 1992 were under 10 gallons. The median size of all facility spills was 2 gallons and the average size was 431 gallons (see Table 5).

Over the 10-year period, the number of facility spills of 10,000 gallons or more dropped dramatically: from an average of 51 per year between 1983 and 1985 to an average of 13 per year between 1986 and 1992. Between 1991 and 1992 alone, the frequency of facility spills declined 55 percent.

The volume of facility spills also declined dramatically: from 5.4 million gallons in 1983 to 0.6 million gallons in 1992—an 89 percent drop (see Figure 6). The bulk of the spills—43 percent—came from onshore facilities such as refineries, loading docks, storage tanks, marketing terminals, and drilling platforms (see Table 6). For these spills, the median was 5 gallons and the average was 642 gallons.

table 5

NUMBER OF OIL SPILLS FROM
FACILITIES BY SIZE: 1983-1992

Year	Under 10 gallons	10-999 gallons	1,000-9,999 gallons	10,000-99,999 gallons	100,000+ gallons	Total
1983	4,503	2,213	290	45	10	7,061
1984	4,113	2,194	288	53	3	6,651
1985	3,032	1,619	252	39	2	4,944
1986	2,076	1,025	54	10	3	3,168
1987	1,821	1,022	66	10	1	2,920
1988	1,730	939	68	6	4	2,747
1989*	2,827	1,140	70	12	2	4,051
1990*	3,904	1,187	72	15	4	5,182
1991	4,102	1,174	68	13	1	5,358
1992	1,787	557	30	10	2	2,386
Total	29,895	13,070	1,258	213	32	44,468

*Data revised by U.S. Coast Guard.

Pipelines were second in volume among facilities. They spilled 41 percent of the total and tended to have the largest spills: 2,886 gallons on average. The median was much lower: 18 gallons. Moreover, more than half the petroleum products that traveled the U.S. between 1983 and 1992 moved by pipeline.

As facility spills declined, so did reports of mechanical and equipment failures as a cause of spills. The timing coincided with the installation of better leak detection devices in pipelines and storage tanks. In pipelines, for example, enhanced cathodic protection helped reduce spills caused by corrosion. Internal inspection devices called "smart pigs" identified pipeline segments requiring repair before leaks could begin. Hydrostatic testing and close interval surveys also helped maintain pipeline integrity.

Other factors may also have contributed to the decline—for example, changes in the Coast Guard's record-keeping system and the drop in accidents involving overturned tank cars.

Nature of spills. Distillates such as heating oil spilled more often than crude oil: distillates, some 26,600 times versus crude oil, some 17,500 times between 1983 and 1992. But the volume of crude oil that spilled was much larger: 3.3 million gallons of crude oil versus 13.4 million gallons of distillates between 1983 and 1992 (see Table 7).

table 6
VOLUME OF OIL SPILLS FROM
FACILITIES BY SOURCE: 1983-1992
(in thousands of gallons)

Year	Natural Events	Airports	LOOP	Offshore Facilities	Onshore Facilities	Pipelines	Railroads	Tank Trucks	Vehicles**	Unknown	Total
1983	no record	4	0.2	117	1,688	3,038	96	64	150	248	5,405
1984	no record	5	0.1	69	1,001	1,194	74	147	143	200	2,833
1985	no record	7	1	42	828	798	78	62	89	272	2,177
1986	0.02	1	0.1	15	885	231	1	18	3	126	1,280
1987	0.1	2	0.2	23	285	201	4	26	4	73	618
1988	3	8	0.2	23	1,347	1,545	3	21	1	47	2,998
1989*	1	.8	0.4	46	410	241	0.3	29	1	68	798
1990*	0	4	0.1	39	978	419	12	14	1	156	1,623
1991	0	.8	0	41	389	48	0.3	6	0.7	369	855
1992	0	64	0	20	366	93	0	—	16	21	500
Total	4	97	2	435	8,177	7,808	269	387	409	1,580	19,167

* Data revised by U.S. Coast Guard.

** Includes tank trucks starting in 1992.

table 7

NATURE OF PETROLEUM SPILLS: 1983-1992

(In thousands of gallons)

Product	Volume of Spills	Number of Spills
Cruise oil	32,971	17,423
Distillates	13,393	26,595
Residuates	6,477	3,594
Gasoline	4,143	6,104
Miscellaneous	3,005	11,299
Lubricants	1,736	7,110
Jet fuel	1,339	987
Kerosene	656	667
Asphalt	480	519
Kapithas	307	343
Unknown	183	2,771
Benzene and related chemicals	147	72
Light ends	58	83
Liquidified petroleum gas	15	47
Waxes	5	23
Sludge oil	3	205
Liquidified natural gas	2	34
Total	64,920*	77,876

*Differs from figure used elsewhere in this report due to rounding.

METHODOLOGY

This report uses U.S. Coast Guard data on oil spills between 1983 and 1992, provided at API's request. Before 1985, the Coast Guard tracked spills with the Pollution Incident Reporting System. Though it included fewer details about spills than the Marine Safety Information System that succeeded it, API was able to use the earlier data to analyze spill volumes, locations, causes, and contents. In 1992, the Coast Guard started tracking spills with another database called the Marine Pollution Retrieval System.

API tried to enhance the accuracy of the Coast Guard's data in several ways. Where the records showed that the amount recovered was much greater than the amount that had spilled, API assumed there had been a data entry error and reversed the two amounts. When the records did not show the date of a spill, API used the case or spill identification number to determine it, as the Coast Guard recommended. If the amount spilled was missing or recorded as zero, API counted the spill as less than one gallon—an approach the Coast Guard endorsed. In addition, API did not count spills of oils not derived from petroleum—for example, vegetable and peanut oil spills.

API also eliminated double-counting caused by duplicate records of the same spill. Sometimes, the Coast Guard created two records when more than one type of oil spilled. API consolidated them, creating one record (with the total amount spilled) classified as one type of petroleum (the one with the largest volume spilled). API also eliminated double-counting of spills from more than one source—for example, a collision of two barges. Here, API created a single record of the total amount spilled.

API verified almost all spills of more than 10,000 gallons in local newspapers and trade publications such as the *Oil Spill Intelligence Report* and *Golob's Oil Pollution Bulletin*. To verify pipeline spills, API also used U.S. Department of Transportation data. If one of these sources cited a spill the Coast Guard had not recorded, API included it—provided a second source confirmed it.

The Coast Guard's records included six spills of one million gallons or more that API could not verify—all in 1985 or earlier. In each case, important information was missing such as the source or location of the spill. Since it is highly unlikely that a spill of such size would go unnoticed—large spills generally receive a great deal of media attention—Coast Guard records of them are most likely data entry errors. And since it is almost impossible for the Coast Guard to locate the information needed to verify these spills, API deleted them from its calculations.

LARGE SPILLS DELETED FROM API CALCULATIONS

August 26, 1983. Crude oil spill of 1 million gallons in Pacific coastal harbor. Cause and source unknown.

January 24, 1984. Grounded barge spill of more than 1 million gallons of No. 6 fuel oil in lower Mississippi River.

April 27, 1984. Land facility spill of 1 million gallons of No. 4 fuel oil in the Great Lakes. Cause recorded as "unintended discharge, improper securing."

November 26, 1984. No. 1-D fuel oil spill of more than 6 million gallons in Atlantic coastal harbor. Cause and source unknown.

February 15, 1985. Land facility spill of more than 1 million gallons of a range of petroleum products in an unknown location.

July 13, 1985. Tanker spill of more than 1 million gallons of mineral seal oil in a Gulf of Mexico coastal river. Cause of spill unknown.

used oil

MODEL USED OIL COLLECTION BILL

API's model used oil collection bill has helped businesses and government agencies create successful programs. For example, a curbside collection program in Houston, Texas—a joint undertaking of the city's Department of Public Works and five oil companies—reached 32,000 households and gathered more than 50,000 gallons of used oil in its first year of operation.

The model bill calls for states to establish a used oil collection fund, which may be financed with an "environmental fee" of 2 to 5 cents per quart of motor oil. The money is distributed to municipalities and government agencies—as grants, subsidies or loans—and used to defray the cost of setting up collection centers, running curbside collection programs, and educating people about handling used oil properly.

In addition, the model bill includes management standards for collecting, transporting, and recycling used oil. And it specifies that businesses willing to serve as collection centers should not be liable for damages associated with contaminated oil do-it-yourselfers might bring to them.

This analysis of used oil collection programs is based on a questionnaire API sent to 17 member companies; 15 responded with information about the number of collection sites they operate, their location, and their weekly volume. To derive annual figures, API multiplied the average weekly volume by 52.

The U.S. Environmental Protection Agency estimates that each year "do-it-yourselfers"—people who change their own motor oil—generate 200 million gallons of used oil. If disposed of improperly, it can contaminate soil and water—both on the surface and underground.

In cooperation with government agencies, oil companies collect about a third of the used motor oil "do-it-yourselfers" generate each year. While most of this oil is burned for energy recovery in industrial boilers, some is refined again and made into other petroleum-based products—for example, lubricants.

API and member companies work with government agencies to create programs to collect used oil—and educate people about them. API has also developed a model used oil collection bill. Florida, California, South Carolina, Texas, Louisiana, Tennessee, and Utah have adopted the entire bill and other states have adopted parts of it. Some states are still studying the bill.

DEFINITIONS

Do-it-yourselfer. Someone who changes his or her own motor oil. Some 50 to 60 percent of American automobile owners change their own motor oil.

Used oil collection site. May be either of two types: drop-off (people bring their used oil to a designated place) or curbside collection (people leave their used oil at the curb for pickup). States, municipalities, and oil companies establish and run used oil collection sites.

RESULTS

When data collection began in 1991, the 15 companies that responded to API's survey operated nearly 800 drop-off collection sites in service stations, convenience stores, and fast oil-change facilities. By 1992, the same companies operated nearly 7,000 centers in 48 states and the District of Columbia (see Table 1). They collected 7.3 million gallons of used oil—about 11 percent of the used oil collected that year.

table 1

DROP-OFF COLLECTION CENTERS
BY STATE: 1992

PAD District 1:		PAD District 2:			
Connecticut	103	Illinois	356	Mississippi	19
Delaware	43	Indiana	89	New Mexico	14
District of Columbia	46	Iowa	70	Texas	413
Florida	704	Kansas	38	Subtotal	602
Georgia	61	Kentucky	32	PAD District 4:	
Maine	7	Michigan	271	Colorado	86
Maryland	320	Minnesota	181	Maine	3
Massachusetts	216	Missouri	113	Montana	12
New Hampshire	26	Nebraska	42	Utah	2
New Jersey	400	North Dakota	61	Wyoming	0
New York	633	Ohio	412	Subtotal	83
North Carolina	120	Oklahoma	21	PAD District 6:	
Pennsylvania	410	South Dakota	77	Alaska	0
Rhode Island	21	Tennessee	107	Arizona	127
South Carolina	42	Wisconsin	122	California	433
Vermont	6	Subtotal	1,876	Hawaii	0
Virginia	270	PAD District 3:		Nevada	0
West Virginia	30	Alabama	12	Oregon	14
Subtotal	3,625	Arkansas	44	Washington	58
		Louisiana	96	Subtotal	608
				Grand total	6,877

More than half the collection sites the 15 companies operated—3,625—were in Petroleum Administration for Defense (PAD) District 1, which includes 17 eastern seaboard states and the District of Columbia (see Figure 1). Florida had the most collection sites, with New York in second place.

The 15 states in PAD District 2 had 1,978 collection sites, primarily in Ohio, Illinois, Michigan, Minnesota, and Wisconsin. The six states in PAD District 3 had 602 collection sites, more than two-thirds of which were in Texas. The five states in PAD District 4 had 83 collection sites, more than three-quarters of which were in Colorado. The five states in PAD District 5 had 689 collection sites, mainly in California.

figure 1

USED OIL COLLECTION CENTERS
OPERATED BY 15 OIL COMPANIES: 1992



workplace safety

This is an analysis of job-related injuries and illnesses in the petroleum industry from 1977 through 1992. It provides data on four major parts of the industry: exploration and production, refining, marketing (wholesale and retail), and oil pipelines.

The source of this information is the U.S. Bureau of Labor Statistics publication, "Occupational Injuries and Illnesses in the United States by Industry"—except for the 1992 data on petroleum workers, which are not yet available. Instead, the 1992 data are from an API publication, "Summary of Occupational Injuries, Illnesses, and Fatalities in the Petroleum Industry." It is based on an API survey that collects much the same information the government does, but defines exploration and production somewhat differently and therefore does not include contract workers.

Throughout the U.S. private sector, job-related injuries outnumber illnesses—for example, 94 percent of the cases the petroleum industry reported in 1992 were injuries. Accordingly, this study examines injuries and illnesses together.

DEFINITIONS

The U.S. Occupational Safety and Health Administration requires employers to record job-related injuries that result in death, loss of consciousness, days of lost or restricted work, transfers to different jobs or medical treatment beyond first aid.

Illness. Any abnormal condition or disorder attributed to prolonged exposure to workplace environmental factors or substances that are inhaled, absorbed or ingested in the workplace. Includes conditions caused by repeated trauma such as carpal tunnel syndrome.

Injury. A single, instantaneous event in the workplace that results in a fracture, cut, abrasion, burn, bruise, other damage to the body or death. Back ailments are an exception in that they are classified as injuries even if not caused by a single event.

table 1

PETROLEUM INDUSTRY AND U.S. PRIVATE SECTOR
OCCUPATIONAL INJURIES AND ILLNESSES: 1977-1992
(per 100 full-time workers)

Year	Exploration and Production	Refining	Marketing			Oil Pipelines	Entire Petroleum Industry	U.S. Private Sector
			Retail	Wholesale	Total			
1977	12.9	5.8	3.9	6.4	4.6	5.0	6.9	9.3
1978	13.9	6.0	4.1	6.6	4.8	4.7	7.6	9.4
1979	13.6	5.6	4.1	6.4	4.7	4.6	7.7	9.5
1980	13.4	5.4	4.2	5.1	4.5	5.2	7.9	8.7
1981	14.1	5.5	3.6	5.6	4.2	4.3	8.4	8.3
1982	12.1	4.1	4.0	5.4	4.4	5.0	7.6	7.7
1983	9.8	3.9	3.6	4.5	3.8	4.2	6.2	7.6
1984	11.8	3.4	3.9	4.2	4.0	4.1	7.0	8.0
1985	10.1	3.4	3.8	4.6	4.0	3.7	6.3	7.9
1986	8.1	5.7	4.6	5.3	4.8	4.5	5.9	7.9
1987	8.3	6.2	4.6	4.9	4.7	4.6	5.9	8.3
1988	8.3	5.8	4.7	5.7	4.9	3.6	6.0	8.6
1989	7.6	5.3	4.4	5.1	4.6	3.5	5.5	8.6
1990	8.0	5.1	4.5	5.4	4.7	3.4	5.7	8.8
1991	6.4	4.9	4.1	5.7	4.5	4.0	5.1	8.4
1992	6.7*	4.2*	5.3*	3.4*	4.5*	3.0*	5.1*	8.9
Change from 1977-1992	-48.1%	-27.6%	35.9%	-46.9%	-2.2%	-40.0%	-26.1%	-4.3%

*Estimated based on 1992 API survey.

RESULTS

Over the 16-year period, job-related injuries and illnesses dropped more than 26 percent for the U.S. petroleum industry—compared to 4.3 percent for the U.S. private sector (see Table 1 and Figure 1).

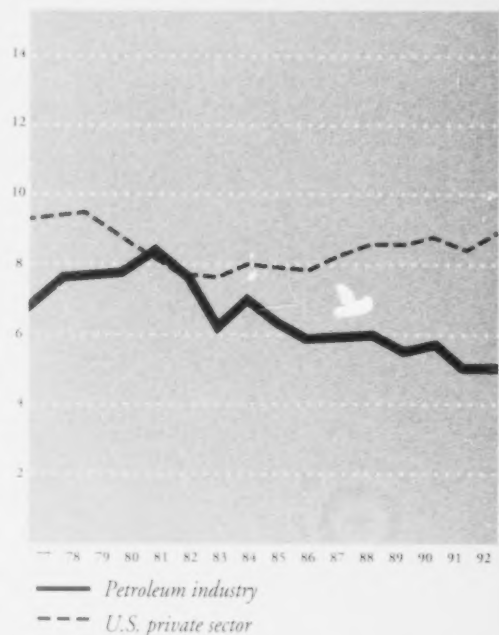
After the Occupational Safety and Health Administration issued new record-keeping guidelines in 1986, the reported rate of job-related injuries and illnesses rose in parts of the petroleum industry—as it did in much of the rest of the private sector. But unlike the private sector as a whole, the industry's overall performance improved by almost 14 percent between 1986 and 1992.

The petroleum industry continues to strive to ensure a safe working environment. For example, API publishes recommended practices on such subjects as managing process hazards and safely operating hydrofluoric acid alkylation units. Training programs and safety seminars foster the exchange of information that helps avoid accidents. In addition, petroleum companies screen employees for drug and alcohol use.

Exploration and production. Job-related injuries and illnesses among full-time exploration and production workers dropped 48 percent (from 12.9 per 100 workers in 1977 to 6.7 per 100 workers in 1992). Most of the decline occurred in the first half of the 1980s. The rate held steady for the rest of the decade, then plunged 16 percent between 1990 and 1992 (see Figure 2).

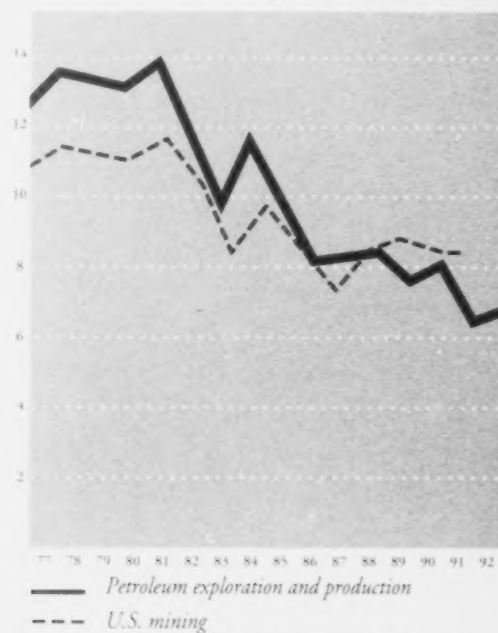
Historically, injuries and illnesses were more common in petroleum exploration and production than other parts of the private sector. That has changed in recent years. From 1988 to 1991 (the most recent government data available), petroleum exploration and production had a lower rate of injuries and illnesses than other extractive industries and the U.S. private sector as a whole.

figure 1
PETROLEUM INDUSTRY AND U.S. PRIVATE SECTOR
OCCUPATIONAL INJURIES AND ILLNESSES: 1977-1992
(per 100 full-time workers)



Injuries and illnesses among petroleum workers dropped 26 percent—compared to 4.3 percent for the entire U.S. private sector.

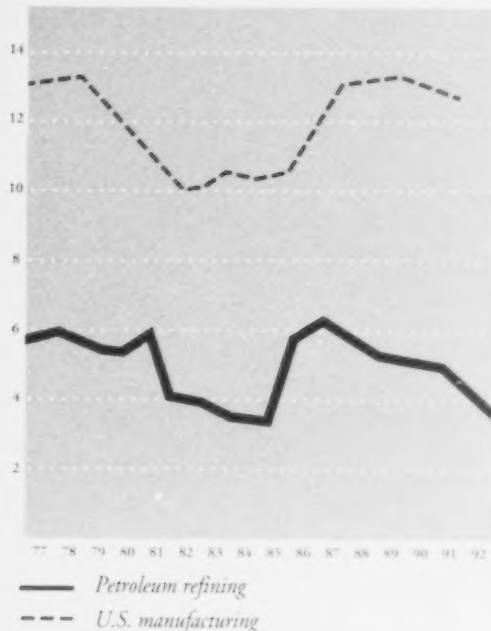
figure 2
PETROLEUM EXPLORATION AND PRODUCTION AND
U.S. MINING OCCUPATIONAL INJURIES AND
ILLNESSES: 1977-1992
(per 100 full-time workers)



In petroleum exploration and production, injuries and illnesses dropped 48 percent.

figure 3

PETROLEUM REFINING AND U.S. MANUFACTURING
OCCUPATIONAL INJURIES AND ILLNESSES: 1977-1992
(per 100 full-time workers)



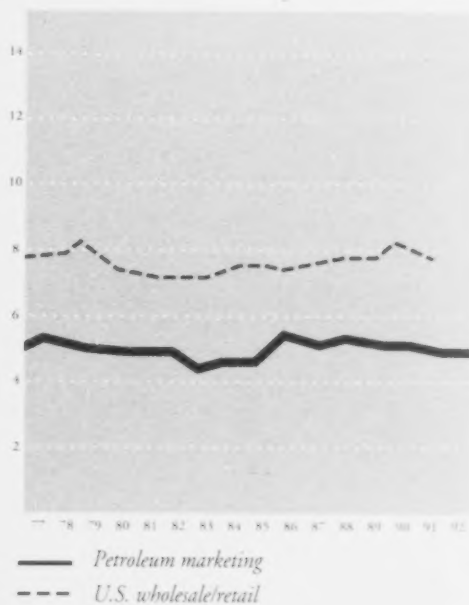
In petroleum refineries, injuries and illnesses dropped 28 percent.

Refining. Job-related injuries and illnesses among full-time refinery workers declined 28 percent (from 5.8 per 100 workers in 1977 to 4.2 per 100 workers in 1992). After a sharp increase in 1986 and 1987—following the introduction of new rules for recording injuries and illnesses—the rate once again declined (see Figure 3). In 1991 (the most recent government data available), the rate of injuries and illnesses among full-time refinery workers was about 61 percent below the average for U.S. manufacturing as a whole (4.9 versus 12.7 per 100 workers).

Marketing. Job-related injuries and illnesses among full-time marketing personnel (wholesale and retail) declined 2 percent (from 4.6 per 100 workers in 1977 to 4.5 per 100 workers in 1992). The rate fell by about 13 percent between 1977 and 1985, but rose in 1986 after new record-keeping rules went into effect. Since then, there has been no apparent trend in either direction (see Figure 4).

figure 4

PETROLEUM MARKETING AND U.S. WHOLESALE/
RETAIL OCCUPATIONAL INJURIES AND ILLNESSES:
1977-1992
(per 100 full-time workers)



In petroleum marketing, injuries and illnesses dropped 2 percent.

Oil pipelines. The rate of job-related injuries and illnesses for full-time oil pipeline workers declined 40 percent (from 5.0 per 100 workers in 1977 to 3.0 per 100 workers in 1992). In the latter half of the 1980s, pipeline workers had the lowest rate of injuries and illnesses in the petroleum industry—lower than any other form of transportation and among the lowest of all the industries for which the government compiles statistics (see Figure 5).

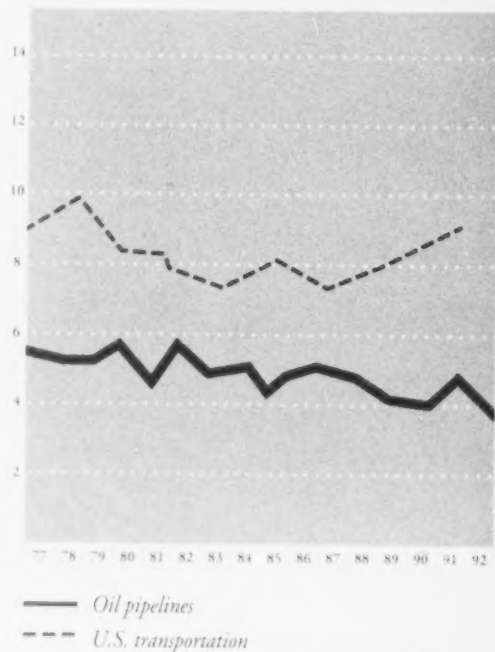
METHODOLOGY

This report uses U.S. Occupational Safety and Health Administration data published by the Bureau of Labor Statistics—except for 1992 data on the petroleum industry, which are estimated numbers from an API survey (government data will be substituted when they become available).

Though API and OSHA request much the same information in their surveys, differences in definitions cause variations in the two sets of data. Even so, for all but the exploration and production sector, for statistical purposes the data are the same; any variations are most likely due to random sampling error.

In exploration and production, however, the data are significantly different. This may be because OSHA includes contract workers and API does not. The rate of injuries and illnesses is likely to be higher among contract workers, who work mostly in exploration and production where risks are greater. Therefore, API quantified the relationship between the two sets of data with polynomial regression models, then estimated a number comparable to OSHA's number.

figure 5
OIL PIPELINES AND U.S. TRANSPORTATION
OCCUPATIONAL INJURIES AND ILLNESSES: 1977-1992
(per 100 full-time workers)



*Injuries and illnesses dropped 40 percent
among oil pipeline workers.*

environmental expenditures



This study details how much the U.S. petroleum industry spent on the environment from 1990 through 1992—and analyzes how it was distributed. It is based on industry-wide surveys of environmental expenditures conducted by API.

API sent questionnaires to a sample of companies representative of the industry as a whole. To ensure consistent responses, API included detailed guidelines and standard definitions. They address a wide range of issues, including identification and allocation of capital expenditures. API reviewed all responses—checking for consistency among companies of similar size and verifying any unusual responses—then developed estimates for the industry as a whole.

Only estimates and aggregate data are presented; the responses of individual companies remain confidential. All reported expenditures are for calendar years 1990 through 1992, and relate to the prevention, control, abatement or elimination of pollution from domestic petroleum operations. Chemical and non-petroleum operations such as coal, shale, and mineral mining are not included.

Reported expenditures do not include reserves or other provisions established for future environmental activities; expenditures to meet U.S. Occupational Safety and Health Administration requirements; fines or penalties associated with environmental activities; estimates of lost revenue or business opportunities; and insurance premiums or recoveries.

DEFINITIONS

API's environmental expenditures survey uses definitions for air, water, and wastes comparable to those used in the annual U.S. Bureau of the Census study, "Pollution Abatement Costs and Expenditures" (report MA-200).

Air. Activities related to the prevention, control, abatement or elimination of pollutants emitted into open air. They include particulates, sulfur and nitrogen oxides, carbon monoxide, hydrocarbons, volatile organic compounds, lead, and other substances designated by the Clean Air Act and the U.S. Environmental Protection Agency.

Corporate programs. Activities of corporate environmental departments and voluntary programs to improve environmental quality—for example, buying and destroying high-polluting cars, collecting used oil, contributing to environmental groups, conducting educational programs, and restoring wetlands.

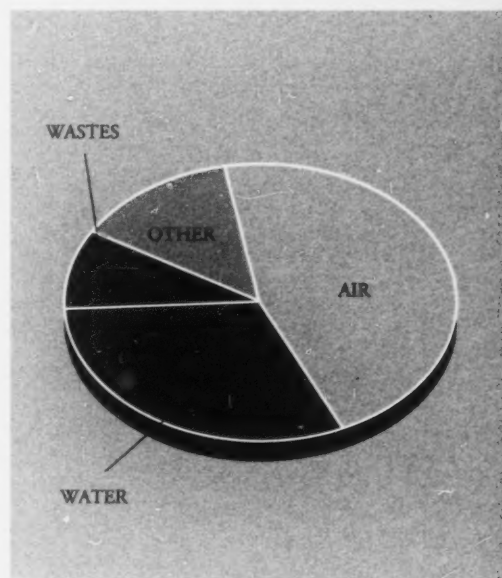
Ongoing activities. Efforts to limit pollution from routine operations. Spending associated with such efforts is divided into two categories: capital and expense (operating, maintenance, and direct administrative costs).

Other activities. Sector-specific environmental activities that are not reported elsewhere—for example, removing abandoned production platforms, supporting oil spill cooperatives, and paying Superfund taxes.

Remediation. Activities to address soil and groundwater contamination, including removal, treatment, and disposal. While such contamination is generally caused by leaks—from storage tanks, pipelines, pits, impoundments or underground piping—it may also result from waste disposal practices allowed in the past, but no longer permitted.

Research and development. Programs that investigate new technologies to limit or reduce emissions from the petroleum industry's products and operations—for example, reformulating gasoline and diesel fuel to reduce motor vehicle emissions.

figure 1
**U.S. EXPENDITURES FOR ONGOING ENVIRONMENTAL
ACTIVITIES BY MEDIA: 1992**
(percent of total spent)



The petroleum industry spends more to reduce air emissions than any other form of pollution.

table 1

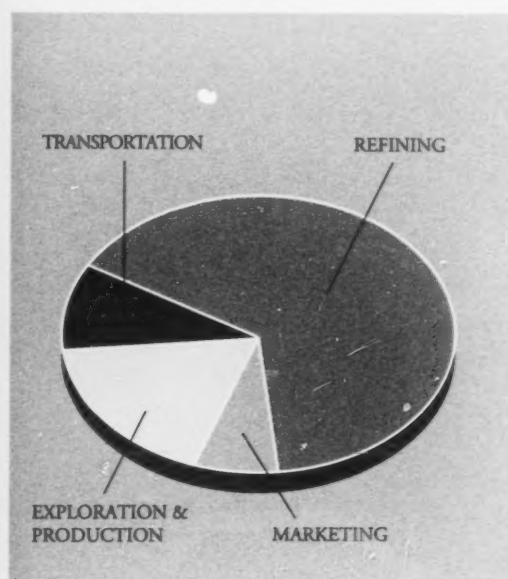
OVERALL U.S. ENVIRONMENTAL
EXPENDITURES: * 1990-1992
(In millions of dollars)

Category	1990	1991	1992
Ongoing activities	6,341	7,054	8,981
Research and development (centralized)	175	227	214
Corporate programs	147	121	78
Remediation and spills	1,117	1,328	1,235
Total	7,780	8,730	10,508

*All expenditures estimated except for remediation and spills, which are actual amounts reported by survey participants.

figure 2

U.S. EXPENDITURES FOR ONGOING
ENVIRONMENTAL ACTIVITIES BY SECTOR: 1992
(percent of total spent)



The refining sector spends more than all other parts of the petroleum industry combined.

Spills. Response and cleanup activities precipitated by sudden malfunctions or accidents. There are two basic types of spills: vessel spills (from boats and ships) and facility spills (from everything else).

Wastes. Activities related to managing solid or contained wastes—collecting, treating, and disposing of such wastes; reducing or eliminating them at the source; and recycling or reusing materials made from wastes.

Water. Activities related to the prevention, control, abatement or elimination of pollutants suspended or dissolved in water. They include solids, oils, metals, toxic chemicals, and other substances designated by the Clean Water Act and the U.S. Environmental Protection Agency.

RESULTS

The petroleum industry spent \$10.5 billion on the environment in 1992—as much as the top 300 oil and gas companies earned in profits that year, according to the *Oil & Gas Journal*. The industry spent more on the environment than it spent searching for oil and gas in the United States in 1992. With oil going for \$16 per barrel at the wellhead, the industry spent \$4 on environmental protection for every domestically produced barrel of oil—\$41 for every man, woman, and child in America.

Overall, the U.S. petroleum industry's environmental expenditures rose nearly 35 percent from 1990 to 1992. The industry spent \$10.5 billion in 1992, \$8.7 billion in 1991, and \$7.8 billion in 1990 (see Table 1). In 1990, the largest share of those expenditures related to preventing water pollution. By 1992, expenditures to reduce air pollution had taken the lead, reflecting the impact of the 1990 Clean Air Act amendments (see Figure 1).

Throughout the three-year period, the refining sector spent the most—more than all other parts of the industry combined—followed by the exploration and production, transportation, and marketing sectors (see Figure 2).

Ongoing activities. Spending to limit pollution from routine operations has risen by 43 percent—from \$6.3 billion in 1990 to \$9.0 billion in 1992 (see Table 2). Much of the increase (see Figure 3) reflects operating changes to comply with the Clean Air Act—for example, equipping refineries to make low sulfur diesel fuel. Capital spending to control air emissions more than tripled, jumping from \$0.8 billion in 1990 to \$2.9 billion in 1992. In contrast, capital spending to control water pollution rose by just 12 percent.

Over the three-year period, expenditures for other activities—for example, removing abandoned platforms, financing oil spill cooperatives, and paying Superfund taxes—rose 46 percent to \$1.1 billion. Spending to manage solid wastes increased more than 38 percent to \$0.9 billion. In all, capital outlays nearly doubled while operating, maintenance, and direct administrative expenses increased less than 10 percent.

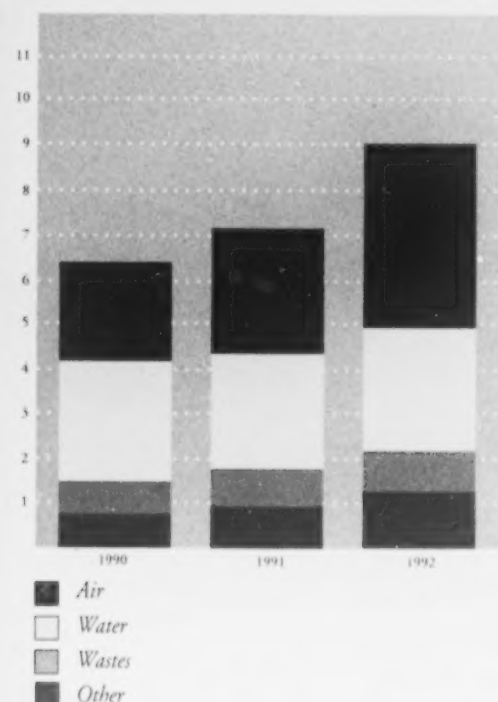
The refining sector's environmental expenditures were \$5.8 billion in 1992—up from \$3.7 billion in 1990. Spending also increased sharply in the transportation and marketing sectors—by about 45 percent. In the exploration and production sector, expenditures remained about the same.

table 2
ESTIMATED U.S. EXPENDITURES FOR ONGOING
ENVIRONMENTAL ACTIVITIES BY MEDIA: 1990-1992
(in millions of dollars)

Sector	1990					1991					1992				
	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total
Exploration and Production:															
Capital	109	424	74	46	653	176	425	76	52	729	173	430	99	41	743
Expense	101	540	92	139	872	106	380	121	217	824	70	393	175	185	823
Transportation:															
Capital	46	149	8	74	277	59	179	4	49	291	81	232	5	47	365
Expense	43	181	15	150	389	79	215	32	120	446	84	294	25	198	601
Refining:															
Capital	601	569	100	16	1,286	1,240	467	65	37	1,809	2,533	573	153	23	3,282
Expense	1,217	620	279	308	2,424	1,002	601	335	371	2,309	1,087	528	333	578	2,526
Marketing:															
Capital	27	163	17	22	229	66	189	28	46	329	77	232	45	12	366
Expense	26	76	80	29	211	28	101	92	96	317	35	92	85	63	275
Total	2,170	2,722	665	784	6,341	2,756	2,557	753	988	7,054	4,140	2,774	920	1,147	8,981

Figure 3

U.S. EXPENDITURES FOR ONGOING ENVIRONMENTAL ACTIVITIES BY MEDIA: 1990-1992
(In billions of dollars)



Expenditures to limit air pollution rose sharply in 1992, reflecting the first implementation of new Clean Air Act provisions enacted in 1990.

Research and development. While a large share of industry spending for research and development occurs within individual sectors, some petroleum companies also have centralized research and development programs. They investigate new technologies to limit or reduce pollution from products and operations. Since motor vehicle fuels are the industry's main product, reformulating fuels to reduce emissions is a primary focus of these efforts.

Spending on centralized research and development programs increased over 20 percent from \$175 million in 1990 to \$214 million in 1992 after dropping slightly—about 6 percent—between 1991 and 1992 (see Table 3). The \$214 million the industry spent on centralized research and development in 1992 included \$137 million to limit air pollution, \$26 million to limit water pollution, \$24 million to manage solid or contained wastes, and \$27 million for other activities.

Corporate programs. These include corporate environmental departments, as well as voluntary programs to improve environmental quality. Such programs vary widely from company to company—for example, developing and supporting environmental education, providing free engine tune-ups, and contributing to environmental groups.

In 1992, the industry spent \$78 million on corporate programs versus \$147 million in 1990 (the decrease may be largely due to a refinement in survey instructions and definitions). Of the \$78 million spent on corporate programs in 1992, \$13 million related to water pollution, \$8 million to air pollution, \$8 million to solid or contained wastes, and \$49 million to other activities (see Table 3).

table 3

ESTIMATED U.S. EXPENDITURES FOR ENVIRONMENTAL RESEARCH AND DEVELOPMENT AND CORPORATE PROGRAMS BY MEDIA: 1990-1992
(In millions of dollars)

Category	1990					1991					1992				
	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total
Research and development (centralized)	102	39	26	8	175	157	37	27	6	227	137	26	24	27	214
Corporate programs	2	3	1	141	147	49	18	5	49	121	8	13	8	49	78
Total	104	42	27	149	322	206	55	32	55	348	145	39	32	76	292

table 4

REPORTED U.S. EXPENDITURES FOR
REMEDIATION AND SPILLS: 1990-1992
(in millions of dollars)

Sector	1990			1991			1992		
	Remediation	Spills	Total	Remediation	Spills	Total	Remediation	Spills	Total
Exploration and Production	82	50	132	78	39	117	84	28	112
Transportation	39	47	86	35	42	77	51	50	101
Refining	273	37	310	256	30	286	180	23	203
Marketing	548	41	589	819	29	848	798	21	819
Total	942	175	1,117	1,168	140	1,328	1,113	122	1,235

Remediation and spills. Expenditures for remediation and spills are unique to each company—therefore, less predictable than other environmental expenditures. For this reason, API does not estimate them for the industry as a whole. The amounts given are simply the sum of the expenditures reported to API.

For remediation and spills, companies that participated in the survey—a stratified sample of the industry—reported expenditures of \$1.2 billion in 1992, \$1.3 billion in 1991, and \$1.1 billion in 1990 (see Table 4). Since the companies reporting vary from year to year, API cannot determine whether this trend is representative of the industry as a whole.

METHODOLOGY

Survey design. API divided the U.S. petroleum industry into three groups of companies using measures of size closely related to expenditures: upstream revenues, trunkline miles, refinery input, refinery capacity, and gasoline sales volumes. The largest companies were in Group 1, mid-size companies were in Group 2, and smaller companies were in Group 3. Size varied little among companies within a group.

To maximize the precision of the overall estimates, all companies in Group 1 and Group 2 were surveyed. Group 3 contained the largest number of companies and was sampled randomly.

Each year, API mailed questionnaires to some 800 companies; roughly 200 responded. As Table 5 shows, the companies that responded to the survey represent a large share—60 to 90 percent—of the variables used to estimate expenditures for the industry as a whole.

Nonetheless, the estimates are based on imperfect data. Many companies do not track environmental spending separately. Others categorize environmental spending differently than the survey does. As a result, some companies are only able to provide a "best estimate" of their environmental expenditures.

API staff extensively reviewed the data individual companies provided to identify inconsistencies. In conducting these reviews, API relied on publicly available information, data from earlier surveys, and data from companies of similar size.

Estimation. To estimate industry-wide expenditures for air, water, wastes, and other activities, API used upstream revenues for the exploration and production sector; trunkline miles for the transportation sector; refinery input and capacity for the refining sector; and gasoline sales volumes for the marketing sector. To develop industry-wide estimates for corporate programs and centralized research and development, API used a combination of these variables.

For the most part, API quantified relationships with regression models and estimated expenditures for each group. When the sample was too small to permit this, data from different groups were pooled. Ratio estimation was used when it produced more precise results than regression models—mainly, in the marketing sector.

table 5

U.S. MARKET SHARE OF
SURVEY PARTICIPANTS: 1990-1992
(in millions of dollars)

Variable	1990			1991			1992		
	Entire Industry	Survey Response	Sample Share	Entire Industry	Survey Response	Sample Share	Entire Industry	Survey Response	Sample Share
Upstream revenues ¹ (billions of dollars)	75.2	44.3	58.8%	65.5	40.2	61.4%	67.7	39.6	58.8%
Trunkline miles ² (trillions of barrel-miles)	3.5	2.6	74.3%	3.5	2.4	68.6%	3.5	2.5	71.4%
Refinery input ³ (millions of barrels per calendar day)	13.4	9.9	73.9%	13.3	10.3	77.4%	13.7	10.7	78.1%
Refinery capacity ³ (millions of barrels per calendar day)	15.6	11.0	70.1%	15.7	11.4	72.6%	15.1	11.7	77.5%
Gasoline sales volumes ⁴ (billions of gallons)	115.9	94.5	81.5%	110.3	94.3	85.5%	114.9	104.1	90.6%

¹Estimate based on API surveys and U.S. Department of Energy, Energy Information Administration, "Petroleum Supply Annual."

²Oil & Gas Journal, "Pipeline Economics."

³U.S. Department of Energy, Energy Information Administration, "Petroleum Supply Annual."

⁴U.S. Department of Transportation, Federal Highway Administration, "Monthly Motor Fuel Reported by States."

Confidence. Standard errors of the estimates can be used to construct a margin of error equal to twice the standard error in either direction—a 95 percent confidence interval. For the sum of all environmental expenditures estimated by API (ongoing activities, research and development, and corporate programs), the estimated margin of error is plus or minus 2.6 percent for 1992, plus or minus 1.9 percent for 1991, and plus or minus 2 percent for 1990 (see Table 6). Assuming survey responses were accurate, API estimates with 95 percent certainty that the U.S. petroleum industry's expenditures for those activities were between \$9.0 and \$9.5 billion in 1992, between \$7.3 and \$7.5 billion in 1991, and between \$6.5 and \$6.8 billion in 1990.

API's calculations of standard errors are based on the variability of the sample, the numbers of sample and non-sample companies, and the methodology used to estimate the expenditures of non-sample companies.

table 6
STANDARD ERRORS OF ESTIMATES BY MEDIA:
1990-1992
(in millions of dollars)

Category	1990					1991					1992				
	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total	Air	Water	Wastes	Other	Total
Exploration and production ¹	3	45	6	7	46	20	53	11	10	59	30	89	13	4	95
Transportation ¹	4	2	2	3	6	2	4	1	3	5	5	20	5	25	33
Refining ¹	41	23	16	2	50	22	22	24	4	39	30	49	23	6	63
Marketing ¹	1	3	0	2	4	1	1	5	1	5	0	18	4	3	19
Research and development and corporate programs ²	1	3	1	2	4	1	0	0	0	1	1	0	0	1	1
Total ³	41	51	18	9	68	30	58	27	11	71	43	105	28	26	120

¹For capital and expense in Table 1.

²For total expenditures in Table 3.

³For the sum of total expenditures in Table 2 and Table 3.

ENVIRONMENTAL PRINCIPLES

The members of the American Petroleum Institute are dedicated to continuous efforts to improve the compatibility of our operations with the environment while economically developing energy resources and supplying high quality products and services to consumers. The members recognize the importance of efficiently meeting society's needs and our responsibility to work with the public, the government, and others to develop and to use natural resources in an environmentally sound manner while protecting the health and safety of our employees and the public.

To meet these responsibilities, API members pledge to manage our businesses according to these principles:

- To recognize and to respond to community concerns about our raw materials, products and operations.
- To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public.
- To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes.
- To advise promptly appropriate officials, employees, customers and the public of information on significant industry-related safety, health and environmental hazards, and to recommend protective measures.
- To counsel customers, transporters and others in the safe use, transportation and disposal of our raw materials, products and waste materials.
- To economically develop and produce natural resources and to conserve those resources by using energy efficiently.
- To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials.
- To commit to reduce overall emissions and waste generation.
- To work with others to resolve problems created by handling and disposal of hazardous substances from our operations.
- To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment.
- To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes.



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